THE HAWAIIAN PLANTERS' RECORD

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"The Record"—A Quarterly

With this number the Hawaiian Planters' Record appears as a quarterly instead of a monthly publication as heretofore. These quarterly issues will come out in January, April, July, and October. The size of each issue will depend upon available material, but will average about 75 pages, varying, perhaps, between 60 and 100 pages in the different numbers. The four issues for the year will comprise a single volume.

Less material will be reprinted from other journals than heretofore, but many articles appearing elsewhere that have an important bearing on the sugar industry of Hawaii will be reviewed or abstracted for the information of our readers. Where important articles of this character are published in foreign periodicals not readily accessible, such material will be reproduced in whole or in part, depending upon circumstances.

The editors of the Record are interested in receiving suitable contributions from individuals connected with the sugar industry of these Islands. Brief articles bearing upon better methods of sugar cane agriculture and manufacture are particularly desired.

Topping Cane for the Mill

In considering the matter of skilled supervision and its bearing on harvesting operations, we found that we did not have adequate data as to the proper point at which laborers should be instructed to top cane when cutting it for the mill. The matter was taken up with Mr. McAllep, and he and Mr. McCleery have conducted an investigation which is reported elsewhere in this number of the Record.

It is interesting to learn that through a consistent error in topping cane at the wrong place we might throw away an amount of sugar great enough to make a serious inroad upon the profits of a plantation.

The report is of a preliminary nature, but it shows that there are commercial possibilities in paying greater attention to this particular operation.

In proceeding with a study of this question we must assume that no stalk of cane can be, or will be, topped at exactly the right point, so that with each stroke of the knife an error occurs which must, at best, amount to a fraction of one per cent of the crop, and often reaches several per cent. The closer the knife can hit to the point which gives us all the recoverable sugar, and prevents the addition of green cane supplying only injurious molasses, the larger will be the yields, and in turn, profits of a plantation.

The extent to which the laborer can reduce the topping error depends upon the information and interest which we can give him in this work. Before attempting to devise ways to improve field practice at this point, the extent of the loss due to imperfect topping must first be ascertained. Upon the sugar value involved will depend the feasibility of corrective measures.

Previous investigations revealed a serious loss in deterioration between cutting or burning and milling, which in many instances has been reduced by more prompt transportation. The topping error deserves the same careful consideration, beginning first with measurements of its extent and bearing on plantation profits.

Studies in Clarification.

Work on clarification problems by W. R. McAllep and H. F. Bomonti, reported in this issue, deals with purity increases from different amounts of lime. The results indicate that there is considerable room for improvement in carrying the reaction of the clarified juice at a more alkaline point than neutrality to litmus, as is the prevailing practice in many factories.

There is a close relation between the phosphoric acid content of the juice and its behavior in clarification. A low phosphoric acid content is accompanied by difficulties in clarification. The results show the possibilities of adding phosphoric acid where this material in present in insufficient quantity.

The cost of such treatment is to be considered in connection with the fact that phosphoric acid so used is recovered in the filter-press mud.

These investigations carry valuable suggestions and the work should be supplemented by further work by factory operators pertaining to their specific conditions.

H. F. Hadfield, in an article which we also publish in this issue, relates satisfactory experience in handling the clarification at a comparatively high alkalinity.

A New Acreage Census of Cane Varieties.

Recent compilations of data, the 1921 acreage census of cane varieties, show a decided reduction in the area of Yellow Caledonia, amounting in round numbers to about 11,000 acres, as against the 1919 census. This shows the effect of a single planting season over the total cane area of the Islands and compares the entire area of the 1922 and 1923 crops with the acreage of the 1920 and 1921 crops.

H 109 shows an increase of nearly 20,000 acres, while Lahaina decreases in area by 16,000 acres. D 1135 continues to show an increase, amounting for this

period to 6600 acres. Striped Tip goes back by 1200 acres, and Yellow Tip gains by 300. Decreases are found for Rose Bamboo and D 117, and increases for Yellow Bamboo, H 146, and in a small degree for Striped Mexican.

The following table shows the situation with respect to cane varieties in condensed form:

VARIETIES OCCUPYING 1000 ACRES OR MORE.

	Census of 1919. Combined Areas of the 1920 and 1921 Crops.	Census of 1921. Combined Areas of the 1922 and 1923 Crops.	Gain in Area.	Loss in Area.
1. Yellow Caledonia	110,695	99,606	.....	11,089
2. H 109	19,826	39,770	19,944	.....
3. D 1135	21,887	28,500	6,613	.....
4. Lahaina	38,329	22,240	.....	16,089
5. Striped Mexican	5,625	5,685	60	.....
6. Yellow Tip	5,191	5,525	334	.....
7. Striped Tip	6,261	5,012	.....	1,249
8. Rose Bamboo	4,578	4,318	.....	260
9. D 117	4,607	3,735	.....	872
10. Yellow Bamboo	950	1,621	671	.....
11. H 146	1,317	1,606	289	.....

Remarkable increase in the area of H 109 and the accompanying decrease of the old Lahaina variety, which has given way to the seedling cane, are shown for a period of eleven crops as follows:

	Acres of Lahaina	Acres of H 109
Crop of 1913................	41,208	0
" " 1914................	39,697	26
" " 1915................	37,394	39
" " 1916................	35,065	558
" " 1917................	33,110	1,160
" " 1918................	33,910	2,847
" " 1919................	28,624	5,414
" " 1920................	25,078	7,147
" " 1921................	16,706	13,471
" " 1922................	14,052	17,501
" " 1923................	8,188	22,269

The figures shown here are subject to minor corrections, as variety areas of a few plantations have been estimated in the absence of statistics from them.

Insect Transmission of Yellow Stripe Disease.

By L. O. Kunkel.

During the past eighteen months a number of experiments have been made in the hope of learning the means by which Yellow Stripe or Mosaic disease is spread to healthy sugar cane plants. Although the problem is by no means fully solved, some of the results seem worth recording at this time.

That many of the mosaic diseases of plants are carried by insects is now a well established fact. The Curly-top of sugar beets, a disease similar to mosaic, is carried by the sugar beet leafhopper *(Eutettix tenella* Baker)[13]; tobacco Mosaic by the spinach aphid *(Myzus persicae* Sulz.)[3]; Spinach-blight, a disease similar to mosaic, by the spinach aphid, the potato aphid *(Macrosiphum solanifolii* Ashmead), the bean aphid *(Aphis rumicis* L.), and the tarnished plant bug *(Lygus pratenis* L.)[10]; potato Mosaic by the potato aphid and the spinach aphid[11]; corn Mosaic by the corn aphid *(Aphis maidis* Fitch)[6]; cucumber Mosaic by the melon aphid *(Aphis gossypii* Glover), the striped cucumber beetle *(Diabrotica vittata* Fabr.), and the 12-spotted cucumber beetle *(Diabrotica duodecimpunctata* Oliv.)[8]; lettuce Mosaic by the spinach aphid[9]; and the Mosaic of mustard and turnip by the spinach aphid.[12] There is evidence that aphids transmit sweet pea Mosaic,[14] tomato Mosaic,[2] and the Mosaic of pokeweed *(Phytolacca decandra* L.).[1]

The fact that insects can carry so many different mosaic diseases suggests that they may be the means by which sugar cane Mosaic is spread. Shortly after beginning the work here reported, Brandes[5] published experiments showing that mosaic is carried to cane by the corn aphid. The importance of aphids in the spread of these diseases naturally brings the cane aphid *(Aphis sacchari* Zehntn.) under suspicion. For this reason it was the first insect used in my experiments.

All plants used in the experiments described below have been grown in soy tubs filled with rich garden soil. Insect control in the earlier experiments was by means of large cloth bags fitted over the tops of the tubs and held in place over the plants by short pieces of bamboo. In all the experiments set up since March 1, 1921, insect control has been accomplished by growing the plants in large insect-proof cages.

Experiments With the Cane Aphid *(Aphis sacchari* Zehntn.)

Experiment 1.—On May 1, 1920, a considerable number of cane aphids taken from a mosaic plant of Striped Tip cane on which they had been feeding for more than a month were transferred to a healthy young plant of the same variety. Another plant of the same age and variety was kept free from insects and used as a control. On July 8, when the experiment was ended, both plants were still healthy.

Experiment 2.—On May 11, 1920, a considerable number of cane aphids, taken from a mosaic Striped Tip plant were transferred to three healthy young plants of the same variety. Three other plants of the same age and variety served as controls. The aphids flourished and were present on the three test plants when the experiment was ended on July 8. They did not transmit the disease.

Experiment 3.—On May 11, 1920, a considerable number of cane aphids, taken from a mosaic plant of the Lahaina variety, were transferred to four healthy

young plants of the same variety. Four other plants of the same age and variety were kept free from insects and served as controls. All plants were still healthy on July 8 when the experiment was ended.

Experiment 4.—On May 26, 1920, a considerable number of cane aphids, taken from a mosaic plant of the Lahaina variety were transferred to two healthy young plants of the same variety. Two other plants of the same age and variety were kept free from insects and served as controls. The aphids flourished on the infested plants but had not transmitted the disease up to July 8 when the experiment was ended.

Experiment 5.—On March 1, 1921, seed from healthy Lahaina cane was planted in each of three tubs of sterile soil placed in three different insect-proof cages. In a like manner seed from mosaic Lahaina plants was placed in three other tubs of sterile soil in the three cages already mentioned. This seed, as was to be expected, gave rise to one healthy and one mosaic plant in each of the three cages. On April 20, when the plants were well started, fifty cane aphids, taken from a healthy Lahaina plant, were placed on each of the mosaic plants in the three cages. The aphids flourished on the mosaic plants and gradually spread from them onto the three healthy plants. All of the three plants from healthy seed were still healthy on July 15, when the plants in two of the cages were thrown out in order to make room for another experiment. The aphids did not transmit the disease to these plants during the period of almost three months that they were present in the cages.

The plants in one of the cages were left undisturbed until October 26. The plant from healthy seed was still free from mosaic on this date. It had produced several lalas and had grown to be a large plant. The aphids did not carry mosaic from the diseased to the healthy plant during the six months that they were present in the cage.

Experiment 6.—It is the habit of the cane aphid to feed on the lower leaves and on the more mature parts of upper leaves. Unless it becomes quite numerous on a plant it is never found on the tender young leaves of the spindle. It was thought that the failure of this insect to transmit mosaic might be due to its habit of feeding on mature tissues. On May 6, 1921, a considerable number of cane aphids, taken from a mosaic plant of the variety Demerara 117, were placed on each of three healthy young plants growing in three different insect-proof cages. Two of the plants were of the Lahaina variety, while the other was of the variety Yellow Caledonia. Approximately one hundred aphids were placed on each of these plants. Three other plants of the same age and varieties were kept free from insects and served as controls. Before placing aphids on these plants all of the mature leaves as well as the mature tips of young leaves were cut off. This was done in order to force the aphids onto the tender young tissues. All plants were still healthy on June 8 when the experiment was ended. The aphids did not transmit the disease even when forced to feed on the immature parts of young plants.

Experiment 7.—On September 19, 1921, a considerable number of cane aphids were transferred from a mosaic plant of the Lahaina variety to ten healthy young caged plants of the variety Striped Tip. Ten other caged plants of the same age and variety were kept free from aphids and served as controls. All

plants were still healthy on October 26, when the experiment was ended. The aphids failed to transfer mosaic disease to the healthy plants.

Two of our most susceptible varieties of cane, Lahaina and Striped Tip, have been used in the experiments with cane aphids. In no case did these insects transmit Mosaic disease to healthy cane plants. Although negative results are never fully convincing, the writer believes that the evidence at hand justifies the conclusion that the cane aphid takes no part in the spread of the Yellow Stripe disease.

Experiments With the Corn Aphid *(Aphis maidis* Fitch).

Experiment 8.—On March 1, 1921, two tubs of sterile soil were placed in each of twenty different insect-proof cages. Ten other tubs of sterile soil were placed outside of, but near, the cages. A seed piece cut from healthy Lahaina cane was planted in one of the tubs while a seed piece cut from diseased Lahaina cane was planted in the other tub in each cage. The ten tubs placed outside the cages were planted with healthy Lahaina seed. On March 21, it was observed that all healthy seed had given rise to healthy plants, while all diseased seed had given rise to diseased plants. On March 28, fifty corn aphids, taken from mosaic corn plants, were placed on each plant in cages numbers 2, 3, 4, 5 and 6. On April 8, fifty corn aphids, taken from mosaic corn plants, were placed on each plant in cages numbers 7, 8, 9, 10 and 11. All caged plants as well as all of the check plants growing outside the cages were examined daily. On April 20, twelve days after aphids were transferred to the last set of cages, it was observed that one stalk of the healthy plant growing in cage number 9 showed three typical Yellow Stripe spots on a young unfolding leaf. The other three stalks of this plant showed no evidence of disease. Seven days later another one of the stalks began to show Yellow Stripe spots on its unfolding leaves. On May 4, the other two stalks began to show the disease. On April 27, nineteen days after the aphids were transferred to the second set of cages, one of the two stalks of the healthy plant in cage number 10 and one of the two stalks of the healthy plant in cage number 11 began to show Yellow Stripe disease. On May 4, Yellow Stripe spots began to appear on the unfolding leaves of one of the three stalks of the healthy plant in cage number 6. The disease appeared on this plant twenty-six days after the aphids were put into the cage.

On May 10, approximately one hundred corn aphids, taken from mosaic corn plants, were placed on each of the plants in cages numbers 2, 3, 4, 5, 7 and 8. No further infection had taken place up to May 22. From this date to June 8 the plants were not under observation as the writer was absent from Honolulu. On June 8, one of the two stalks of the healthy plant in cage number 5 showed Yellow Stripe disease. The plants from healthy seed in cages numbers 2, 3, 4 and 7 were still healthy on July 16 when the experiment was ended. On this date the plants were approximately six feet high and were making vigorous growth. All of the check plants grown from healthy seed in cages numbers 1, 12, 13, 14, 15, 16, 17, 18, 19 and 20 and all of the ten check plants grown outside of cages were still healthy when the experiment was ended.

Six out of the ten healthy caged plants on which corn aphids were placed took Yellow Stripe disease, while the twenty healthy plants on which no aphids were

placed remained healthy. The experiment confirms the results obtained by Brandes and shows that this insect can carry the disease to cane.

Experiments With the Corn Leafhopper *(Peregrinus maidis)*.

Experiment 9.—On March 21, 1921, twenty-five corn leafhoppers, taken from mosaic corn plants, were transferred to each of two cages. Each cage contained one healthy and one diseased Lahaina cane plant. The plants were about a foot in height when the insects were transferred to them. On March 24, twenty-five more leafhoppers were transferred from mosaic corn plants to each of the cages. The insects deposited many eggs in both the healthy and diseased cane plants. A few young hoppers were hatched in each cage, but both colonies gradually died out. On April 21, twelve corn leafhoppers, taken from mosaic corn plants, were transferred to each of the cages. On June 8, when the experiment was ended, no leafhoppers could be found in either of the cages. Both of the plants from healthy seed were still healthy on this date. This experiment indicates that the corn leafhopper is not able to carry the disease to cane.

Experiment 10.—On September 27, 1921, a considerable number of corn leafhoppers, taken from mosaic corn plants, were transferred to two cages containing two healthy young corn plants and one healthy young cane plant each. The cane plants were of the Striped Tip variety. Two other cages containing corn and cane plants of the same age and varieties were kept free from insects and served as controls. On October 14, it was observed that all of the corn plants exposed to corn leafhoppers had contracted Mosaic disease; the cane plants were still healthy. On this date the diseased corn plants were cut off at the surface of the ground and left in the cages to wither. When the corn plants were dry the hoppers went onto the cane plants in large numbers. All of the cane plants used in this experiment and all of the corn plants not exposed to leafhoppers remained healthy up to October 26, when the experiment was ended. The experiments prove that corn leafhoppers can carry mosaic to healthy corn plants, but indicate that they cannot transfer the disease to healthy cane plants.

Experiment 11.—On October 26, 1921, approximately twenty-five corn leafhoppers, taken from mosaic corn plants, were transferred to a cage containing six healthy young corn plants. Six other corn plants of the same age were kept free from insects and served as controls. On December 8, 1921, when this experiment was ended, all of the six corn plants exposed to leafhoppers were infected with mosaic. The six control plants were all healthy. This experiment confirms Experiment 10 and proves that corn leafhoppers can transmit mosaic from diseased to healthy corn plants.

Experiments With the Cane Leafhopper *(Perkinsiella saccharicida* Kirk).

A few tests have been made in order to determine whether or not the cane leafhopper can transfer mosaic to healthy cane plants. The results thus far obtained are negative. As work with this insect is still in progress, the experiments will not be given in detail at this time.

Discussion.

Of the many plants that have been grown in insect-proof cages during the past year, not a single one has taken Mosaic disease unless it was exposed to insects. During all of this time there has been more or less spread of mosaic to cane and corn grown in small garden plots a short distance from the cages. There seems to be good evidence that the spread of mosaic in the fields is by insects. At the present time the corn aphid is the only insect known to carry mosaic to cane. It is fortunate that the cane aphid and cane leafhopper do not carry the disease. The corn leafhopper carries mosaic from corn to corn, but does not seem able to carry it from corn to cane or from cane to cane. Brandes [5] found that corn aphids can transfer mosaic from cane to sorghum and from sorghum to corn. His results indicate that the mosaic of cane is identical with that of sorghum and corn. If these diseases are identical it is rather strange that the corn leafhopper, which so readily transfers corn mosaic to corn, is unable to transfer it to cane. This insect is chiefly responsible for the spread of mosaic in the corn fields of Hawaii.

It seems improbable that the corn aphid is the only insect that takes part in the spread of mosaic to healthy sugar cane fields. Further experiments are expected to show that other insects are able to carry the disease to cane. It is interesting to note that the corn aphid does not thrive on sugar cane. It cannot, in fact, maintain a colony on this plant. In the experience of the writer, eleven days is the longest period of time that any corn aphids have been able to live on cane plants. Most of them die after one week. It is not believed that this insect can invade cane fields to such an extent as to be of any importance in the spread of mosaic from diseased to healthy cane. If, however, a suitable host plant subject to the same mosaic disease is present in or near cane fields, this aphid may become a serious means of spreading the disease. During the past year it was observed that mosaic had spread very rapidly in a field of young plant cane. On examination it was found that goose grass *(Eleusine indica* Gaertn.) was growing as a weed in this field. The grass was quite generally infested with corn aphids* and some of the plants had mosaic disease. Shortly before the spread of mosaic to the cane, most of the goose grass had been cut in an effort to clear the field of weeds. It is believed that in this instance the corn aphids went onto the cane when the grass was cut. In so doing they probably carried the disease from the grass to the cane. Some of the worst epidemics of Yellow Stripe have occurred in cane fields adjoining or near corn fields. It is probable that at least a part of the spread in these fields can be attributed to the corn aphid.

Although the corn aphid is not classed as a cane parasite in Hawaii, it has been reported on this plant in Java, and in a recent letter Dr. Brandes states: "I myself have seen it on sugar cane in the fields of Georgia and can assure you that under greenhouse conditions in Washington it is sometimes so abundant as to almost cover young plants." The observations of Dr. Brandes sug-

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* The aphids were identified by H. T. Osborn of the Department of Entomology of the Experiment Station of the H. S. P. A.

Goose grass, a weed that is subject to mosaic and harbors the corn aphid.

gest that the strain of *Aphis maidis* in the greenhouses at Washington and in the fields of Georgia is different from the one present in Hawaii.

The exact number of weeds and grasses on which this insect flourishes is not definitely known. It doubtless lives on many plants on which it has not yet been reported. It is known to breed on the following plants: Corn, sorghum, broom corn, barley, wood sorrel *(Oxalis* sp.), foxtail *(Setaria glauca* (L) Beaw.), panic grasses *(Panicum crus-galli* L., *P. sanguinale* Seem., *P. dichotomiflorum* Michx.), knotweed *(Polygonum pennsylvanicum* L.[7]), goose grass *(Eleusine indica* Gaertn.), and the club rush *(Scirpus maritimus* L.)* It is probable that the mosaic occurring on some of these grasses is identical with cane mosaic. Brandes[5] has shown that the mosaic on cane is the same as that on sorghum by transferring

* Otto H. Swezey found corn aphids on the club rush in Kapiolani Park, Honolulu.

the disease from cane to sorghum. In discussing other host plants he says: "With regard to sorghum, crab-grass, foxtail and Panicum our evidence is conclusive and proves that the infectious material or virus is the same for all of these plants." [4]

Mosaic is known to occur in Hawaii on the following plants belonging in the grass family: Sugar cane, sorghum, corn, Sudan grass, wonder forage grass (*Andropogon* sp.) and goose grass.

All crops that harbor the corn aphid and all grasses subject to mosaic disease should be grown at some distance from sugar cane fields. Keeping fields free from weeds and wild grasses is to be recommended, not only because this is good agricultural practice, but because it will help to prevent the spread of the Yellow Stripe disease.

Summary.

1. The corn aphid can transfer the Yellow Stripe disease to cane.
2. Experimental evidence indicates that the cane aphid and the cane leafhopper do not carry the disease.
3. The corn leafhopper readily transfers mosaic from diseased to healthy corn plants, but is unable to carry it from cane to cane or from corn to cane.

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Direct and Indirect Injury to Plants by Insects.

By F. Muir.

The injury done to plants by insects is of two kinds, direct and indirect. In the former case it is purely mechanical, such as eating the leaves, stems or roots or by sucking the juices The borer and anomala beetles and the leafhopper are examples of such injury. In the case of indirect injury the mechanical harm done is very slight, the chief damage being done by foreign bodies being introduced into the plant by the insects. The mosaic disease is an example of this.

In the early days of economic entomology, attention was concerned solely with direct injury. and even today our greatest efforts are being made to counteract such injuries. But as knowledge of plant diseases has increased it has been found that insects play an important role in their distribution, even as some insects have been found to carry diseases between man and man, and between various animals and birds. As carriers of diseases, the insects act in two manners. They can form an intermediate host in which the parasite undergoes part of its life cycle, and without such a host it is unable to extend the boundaries of its activities; the malaria parasite and the mosquito is such a case. Or they can act purely as mechanical carriers and simply convey the disease from one party to another without the parasite undergoing any part of its life cycle during the period of transition. As simple carriers they can form a reservoir in which the parasites live (generally internally) for long periods, but undergo no transformation, or they can simply convey them externally on their mouth organs or body.

The method of conveyance is of great economic importance, for intermediate hosts and reservoirs when once infected carry the disease over long periods and inoculate many victims, whereas the simple carrier can carry the disease only for a limited period after being contaminated and can inoculate only a very limited number of victims.

Fighting an insect that does direct damage is generally a simpler matter than fighting one that does indirect damage. By the introduction of beneficial insects into our cane fields we have reduced the damage done by directly injurious insects to such a point that their damage is relatively small; but if they had been indirectly injurious insects I doubt if the reduction would have been great enough to produce very beneficial results. As an example I can cite the leafhopper, which has been reduced to such a degree that it now does no injury except in one or two comparatively small areas. But if it were a carrier of a disease, such as mosaic, then the present reduction would not be sufficient to be very beneficial. One or two leafhoppers on a stool of cane could do no direct injury, but a single leafhopper conveying a disease would be enough to infect the cane.

Thus we see that the control of directly injurious insects is a very different problem to the control of an indirectly injurious insect, and generally a more simple task.

In Hawaii, mosaic disease is not nearly such a serious disease as in Porto Rico, and it would be of great interest to know why this is so. At present it looks as if this may be due to certain insects in Porto Rico which convey the

disease directly from diseased sugar cane plants to healthy sugar cane plants, whereas all of Dr. L. O. Kunkel's experiments indicate that we have no such insects in Hawaii, and the only conveyors are occasional visitors to the cane plants. There is another possibility, that a disease becomes more virulent if conveyed by one insect than it is when conveyed by another insect. There is an indication that this is so in malaria when conveyed by different species of mosquitoes.

In Trinidad the damage done by the Cercopid leafhopper is not by the young feeding upon the roots, but by the adults which feed upon the leaves and cause them to die. From published colored plates of affected leaves it looks as if the leafhoppers conveyed a disease to, or injected a poison into, the leaves. The spot where they puncture the leaf to suck the juice (in a similar manner to our sugar cane leafhopper) becomes discolored and dies. The dead area increases very rapidly and soon the whole leaf is dead. Experiments have been made to see if this was the cause of the stunted growth. All the larger leaves were stripped from cane plants and this was found to cause the same stunting of growth as when the leaves were killed by leafhopper attacks. It is therefore possible that the Trinidad leafhopper is indirectly injurious.

This all demonstrates the necessity of keeping out all insects from our islands, except those whose beneficial natures have been fully demonstrated, for an apparently harmless insect may be a conveyor of diseases. It also demonstrates the necessity of using the utmost care should canes be brought into the Territory, for they may contain the germs of a disease which insects already in the Territory may be capable of conveying.

On account of their method of feeding, the Homopter, or leafhoppers, plant-lice, jumping plant-lice, scales and mealy bugs, are the most liable to be conveyors of diseases, and on this account their economic importance becomes greater than suspected until recently.

Field Methods Used at Waipio.

One of the plantations asks the following questions concerning the methods used to produce the field of cane at Waipio inspected in December by those in attendance at the annual meeting of the Association:

1. When was this field last harvested?
2. How long was the water off this field prior to harvesting?
3. How many months prior to harvesting was the last application of fertilizer made?
4. After harvesting, when was the first application of water made, and how much in acre-inches?
5. How often were subsequent applications of water made, and the amounts in acre-inches?
6. Dates of all fertilizer applications, amounts, and the chemical analysis of fertilizers?
7. Analysis of the soil as to potash, phosphoric acid and nitrogen content prior to first application of fertilizer for this crop?
8. When will this field be harvested this year?
9. Do you intend to carry out the same program for next crop?
10. When this field was planted, kindly give date, space of seed with relation one to the other, and kind of seed; that is, body, top, etc.
11. For first ratoons, how much re-planting was necessary?
12. How much weeding was done in this field?
13. Any other data you may think we may be interested in.

The following answers to these questions have been drafted by J. A. Verret, who has had supervision of this work at Waipio:

1. The last crop (plant cane) was harvested in late May and early June, 1920.
2. The last irrigation was started on January 8, 1920.

   From January to May we had the following rainfall:

January, 1920	6.68	inches
February, 1920	.72	"
March, 1920	4.58	"
April, 1920	.72	"
May, 1920	1.67	"

   For best results at Waipio the water should be taken off from 60 to 90 days before harvest, depending on how fast the field dries out.
3. The last application of fertilizer, consisting of 650 lbs. of nitrate of soda, was made one year before harvest, in May, 1919.
4. It is our policy to put on the first water as soon behind the cutters as possible. We do not wait until the whole field is harvested before starting, but as soon as a level ditch is cleared we irrigate that part. This is generally within a week after cutting.
5. The average irrigation interval was 20 days. In the hot, dry summer months we endeavor to make the rounds every 15 to 16 days. From December, 1920, to February, 1921, there was no irrigation for a period of 74 days on account of rain.
6. The plant crop, harvested in 1920, was fertilized as follows in pounds per acre:

   450 pounds ammonium sulfate on August 12, 1918.
   580 pounds nitrate of soda on October 24, 1918.
   650 pounds nitrate of soda on May 29, 1919.

   This supplied 280 pounds of nitrogen per acre.

The present ratoon crop was fertilized as follows:

667 pounds of nitrate of soda on July 1, 1920.
666 pounds of nitrate of soda on September 20, 1920.
400 pounds of acid phosphate on September 20, 1920.
666 pounds of nitrate of soda on February 11, 1921.

This amounts to 310 pounds of nitrogen per acre.

7. The following is the analysis of the soil from this field:
   Total acid soluble potash (K_2O)=.25%.
   Total acid soluble phos. acid (P_2O_5)=.33%.
   Total citrate soluble phos. acid=.003%.
   Total nitrogen=.13%.
8. This field will be harvested again next April or May, this to depend on the time of the winter rains.
9. The next crop will be a short ratoon to be harvested about August, 1923. The treatment will be about the same, except that probably slightly less nitrogen will be used, about 280 to 290 pounds per acre.
10. The field was planted in May and June, 1918, and was not cut back. Top seed was used, lapped about one inch. Small poor seed pieces were discarded.
11. There was practically no replant needed in the first ratoons. This is fortunate, as with this system of quickly starting the new crop, the replant has no chance to come through unless done very early. What replanting is to be done we now endeavor to do with the first water. We go over the field very carefully and fill in gaps and missing stools. In this way the seed comes up almost as soon as the ratoons, and is not choked out as is the case if replanting is delayed until the ratoons have made some growth.
12. We have no charges for weeding against this field. What few weeds came up were easily taken care of by the irrigators without slowing down the irrigating. With the heavy growth of cane, weeds have no chance to mature seeds, so the only weeds we have to contend with are those from the few seeds coming down with the water.
13. We do not cut back at Waipio. The cane is kept growing as fast as possible, more particularly during August and September every effort is made to see that it suffers no check. We have at present a field of about 10 acres in short ratoons, from cane cut last April. We have been able to find but three tassels on this field. This area has been fertilized as follows:
    June 1, 1921—810 pounds nitrate of soda.
    June 1, 1921—350 pounds of acid phosphate.
    August 5, 1921—810 pounds of nitrate of soda.

    The average time of an irrigation round has been 17 days (not including the rainy season). The field has had no cultivation or weeding of any kind. We estimate 9 or 10 tons of sugar at harvest next August.

We employ at Waipio a system of handling our fields, developed by Mr. Verret, which is designed to take full value of the available area and growing time. There follows his description of this system.

We endeavor always to have two-thirds of the area in long ratoons or plant, and one-third in short ratoons. Each year we harvest two-thirds of our total area, one-half of which is long ratoons or plant and one-half short.

In harvesting we begin with the long ratoons, finishing about June. All these fields then go into short ratoons for the next crop. We then harvest the short ratoons, these fields in turn becoming long ratoons for the crop two years hence. In this way no cut back is needed. We obtain two crops in three years, the average cane being 18 months old at harvest, none of which should ever be over two years old or less than 16 months. In this way we attempt to obtain the utmost returns from the land by doing away with idle time.

Last year we obtained 0.553 tons of sugar per acre per month from our plant and long ratoons, so if we lose a month's growing time we lose that much sugar. This amounts

to 37 pounds of sugar per day per acre. At four cents a pound that gives a "growing time" value of $1.48 per day per acre.

We feel that such success as has thus far been attained at Waipio in producing high yields of cane is due in part to this practice of placing a potential money-value or sugar-value on each acre-day or acre-month. In first proposing sugar-per-acre-per-month as a standard for comparing yields, in the annual report of the Station for 1918, we had this to say:

In comparing cane yields, the length of the growing season often varies to such an extent as to make the usual standard of tons-of-sugar-per-acre a deceptive one. We have recently found much of interest in comparing our cane yields at the Waipio substation on a basis of tons-of-sugar-per-acre-per-month. The correct way to employ this standard is to throw all idle time and all growing time prior to cutting back into the period of the succeeding crop, as this gives a value to this lost time and works toward reducing it to a minimum. On plantations where land is abundant and there is opportunity to fallow, the proposed standard of comparison has not the advantage that it will have on plantations which practice intensive cultivation and desire to make the most of every area of land during every month in the year.

With the knowledge, for instance, that a piece of land may produce sugar at the rate of .3 to .4 ton of sugar per acre, a single acre of land assumes a value potentially of a gross return of about one dollar per day, and lost time in getting a new crop under way can be rated accordingly. Such an estimate applies to the average of the whole year, but lost time in an active growing period assumes an enhanced valuation.

The system also offers an opportunity of deciding accurately between the merits of long cropping and short cropping. A field yielding 4.4 tons of sugar during an 11-month period is producing sugar at the same rate as a field which produced 10.8 tons of sugar in 27 months, though at first glance we are apt to think that one is a poor yield and the other a very excellent one.

It is interesting to observe that in giving an illustration of this system of measuring yields three years ago, we considered .3 or .4 ton-per-acre-per-month a satisfactory realization and gave .48 as the maximum attained. At that time we looked on .5 as a goal to achieve.

In recently reporting the 1921 yields at Waipio, the developments of three years' time are reflected in yield figures that show an average of .553, a maximum of .664, and a minimum of .383.* A yield that was satisfactory three years ago would today be ample cause for an investigation.

While fertilizers and field methods, *per se*, have played an important part in these better yields, such agents could not have been employed to the same advantage without the attitude toward sugar production that gives a full consideration to the potential value of the acre-day. If this amounts to 37 pounds of sugar, all operations must be so regulated that 37 pounds will be realized in practice. Fertilization, irrigation, and other procedures must take place on schedule time. If some neglect must occur through adverse circumstances, such as a shortage of labor, we let it occur where it has the least effect on the potential production per acre-day. Careful estimations are required to determine such a point. This is one of many things that will make close technical supervision of all plantation operations a very profitable undertaking once its merits are recognized.

H. P. A.

* Part of this area was not fertilized.

Notes on Irrigation at the Waipio Substation.

By J. A. Verret.

The impression prevails in some quarters that to produce the rather large yields of cane reported from Waipio, great amounts of water are used.

It was therefore thought that it would be of interest to report on the exact amounts of water used to produce the 1921 crop at Waipio.

These figures are given in the following table:

Field	Irrigation Intervals — Days	Total Acre Inches per Acre	Acre Inches per Acre per Irrigation
A, L. Ratoons	21	98	4.7
B, " "	20	138	6.6
C, " "	21	101	5.0
D, " "	21	145	6.9
E, " "	20	137	6.5
F, " "	20	140	6.7
G, " "	21	122	5.8
H, " "	19	118	5.6
I, " "	21	131	5.9
S, " "	21	129	5.9
U, " "	22	133	6.0
V, " "	22	119	5.7
No. 27, "	21	129	6.2
T, Plant	17	132	4.6
No. 19, Plant	16	199	6.8
No. 37, S. Ratoon	..	85	...
Average	20	139	5.9
Rainfall	..	48	
Total	..	187	

Total water used = 21,073 tons per acre.
Sugar produced = 9.85 tons per acre.
Tons of water per ton of sugar = *2,140*.

Experiment A, given above, was an irrigation test where part of the area was irrigated every other line. That accounts for the smaller amount of water used.

From the above table we find that the average interval between irrigations was 20 days. This interval varies to some extent with the season. In the warm, fast growing periods we make the intervals somewhat shorter, while in winter they are longer. The 20-day interval given above does not include periods when there is no irrigation on account of rain.

The total irrigation water used amounted to 139 inches, the rainfall was 48 inches, making a total of 187 acre inches per acre for the crop.

The average amount of water applied per acre per irrigation is found to be 5.9 acre inches. This is slightly more than the amount actually used per regular irrigation as it includes "dry spot" irrigation.

A number of our fields contain pali's which dry out faster than the other areas. These dry spots receive extra irrigations.

The total water used amounted to 21,073 tons per acre. The average yield of sugar was 9.85 tons per acre. The tons of water per ton of sugar was 2,140.

In reports read at the annual meetings at different times and including plantations on Oahu, Maui, and Kauai, the average tons of water per ton of sugar is given as 3,898, which is almost twice the amount used at Waipio.

The water at Waipio is measured as it leaves the reservoir by means of a venturi meter. This meter has been carefully tested and is accurate. The seepage from the reservoir is also included.

Value of the Upper Joints of Cane.

By W. L. McCleery.

It is known that the top of sugar cane contains less sucrose and more impurities than the lower portions, though there seem to be few data regarding the manufacturing value of the upper joints, from which conclusions can be drawn as to the proper point for topping. There is apparently no information available concerning a common point of identification near the top of the stalks which is easily recognizable and that can be applied to all sticks of cane.

Brown and Blouin, in Louisiana Experiment Station, Bulletin No. 91, report decreased coefficients of purity and increased amounts of glucose in the juices obtained from succeeding joints of cane starting from the butt toward the top.

Dr. Norris, in the Hawaiian Planters' Record III, 128, gives results of some work done at this Station. Samples of cane were selected which had been topped so that about six or eight inches of the green leaves were left on the stalks. In each sample the top, including the first joint below the green leaves, was separated from the rest of the stalk, and the juices from the two portions analyzed separately. The average of five tests showed:

	Brix	Polarization	Purity
Top	9.1	4.8	52.7
Remainder	18.0	16.4	91.1

In all of the above work the juices were extracted under varying conditions, and no data are given as to pressure applied, nor information correlating the juice purities with the normal juice. It was therefore thought advisable to make a larger number of determinations in order to have as much information at hand as possible.

The greatest difficulty about an investigation of this kind is to find a reference mark which is strictly comparable and capable of duplication with all sticks of cane. After examining a number of sticks it was noticed on each,

that the first leaf tightly wrapped for the full length of its sheath was attached to the node above the joint, which for the lack of a better expression we have termed the *last weathered joint.* The leaf growing from the lower node of this joint having started to separate has allowed it to become weathered and assume an appearance of maturity. While this point is not all that could be desired as a reference mark, it seems to be fairly capable of being duplicated on all stalks of cane. This point can also be recognized on burned cane, as the tightly wrapped green leaves are not affected by the fire.

The accompanying illustration shows one cane top, A, with the leaves removed. B is a top with the leaves removed to the lowest tightly wrapped leaf. C shows the sections made by cuts at the center of the different nodes. The last weathered joint described above lies between the figures two and three, and has a white thread tied around its center in both A and B.

As a preliminary experiment, 29 sticks of H 109 cane grown at the Experiment Station were used, large, small and medium sized sticks being included. Cuts were made at points indicated by lines in the illustration. The joints taken for analysis were those opposite Nos. 1, 2, 3 and 4. The adhering leaves were included in the samples. It will be noted that Samples 1 and 2 were below the center of the last weathered joint, and 3 and 4 above.

The samples were chopped very fine so that the largest pieces were not over a quarter inch in diameter. They were then placed in bags and the juice expressed under about 1200 lbs. pressure per square inch. The analyses made included Brix, polarization, sucrose, glucose and ash on the expressed juice, and fiber, moisture and polarization on the residual cake. Records were made of weights on all samples so that the analysis of the original cane could be reconstructed. The stalks below sample No. 1 were ground in a small mill, expressing about 50% of the juice. Following are the analyses:

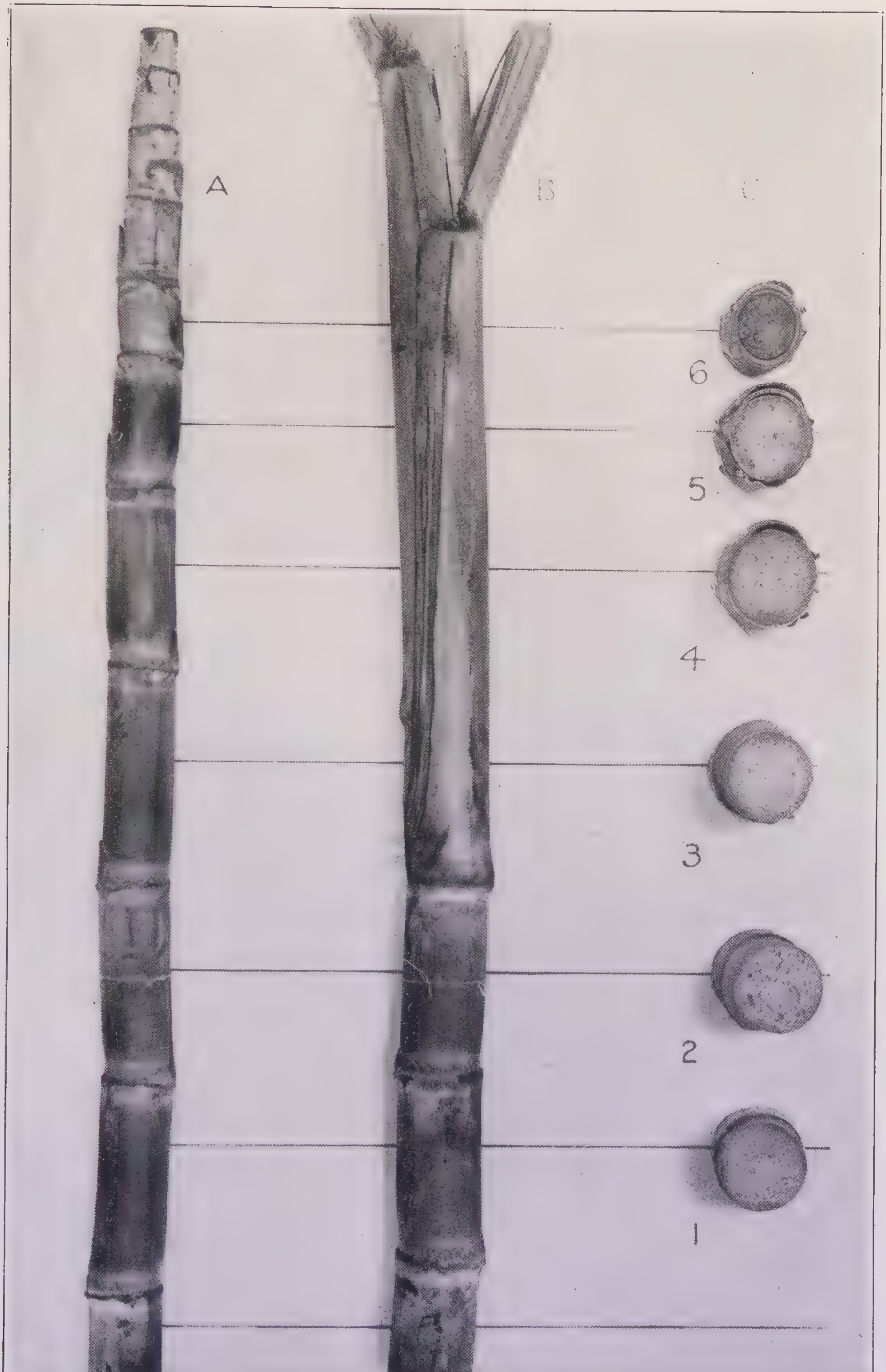
JUICE

Joint	Brix	Ap. Pur.	Gr. Pur.	Glucose	Ash	Juice % Cane	Juice % Juice	Glucose to Ash	Sucrose to Ash
No. 0 ..	21.4	91.8	....	....	....	....	....	....	.....
No. 1 ..	19.4	80.2	81.4	1.05	0.82	73.5	81.9	1.28	19.29
No. 2 ..	18.0	73.8	75.3	1.42	0.93	75.0	83.3	1.53	14.58
No. 3 ..	16.0	66.6	68.9	1.76	1.11	75.0	83.4	1.59	9.92
No. 4 ..	14.1	56.1	58.1	2.10	1.33	75.0	83.3	1.58	6.16

"0" is the juice from the remainder of the stalks below joint No. 1.

RESIDUAL CAKE

Joint	Per Cent	Pol.	Fiber	Moisture	Solids Not. Pol.	Pur. Residual Juice
No. 1	26.5	8.6	38.7	50.0	2.7	76.1
No. 2	25.0	7.7	39.8	50.0	2.5	75.5
No. 3	25.0	6.4	40.2	50.7	2.7	70.3
No. 4	25.0	5.2	40.0	50.9	3.9	57.1



A, Cane top with its leaves removed. B, Similar top with the leaves removed to the lowest tightly wrapped leaf. C, Sections made by cuts at the centers of the different internodes.

CANE ANALYSIS CALCULATED FROM ABOVE DATA

Joint	Sucrose	Fiber	Normal Juice			
			Brix	Pol.	Ap. Pur.	Gr. Pur.*
No. 1	13.9	10.3	19.3	15.3	79.5	80.6
No. 2	12.1	10.0	17.8	13.2	74.1	75.3
No. 3	9.9	10.1	15.9	10.7	67.2	69.4
No. 4	7.4	10.0	14.3	8.0	56.3	57.9

* The apparent and gravity purity of the juice left in the cake was assumed to be identical. No appreciable error is introduced by using this figure.

In applying the S. J. M. formula to these results the writer has used the gravity purity of normal juice and assumed a final molasses of 37 gravity purity. This the writer believed to be conservative, for it will be noted that the purity used is the gravity purity of the normal juice and not that of the expressed juice. Under factory conditions the purity of the juice recovered should be somewhat higher than the normal juice purity. The above assumption makes no allowance for increase of purity during clarification. Such an increase might reasonably be expected. In the joints where the purity is lowest the glucose is high, a factor which favors the production of low purity molasses. With the assumption indicated above, using the S. J. M. formula the following percentages of total sucrose are recoverable

Joint No. 1	85.9%	Joint No. 3	74.2%
" " 2	80.8%	" " 4	57.4%

The weight of the topped cane was 52.25 lbs. The following table shows the percentage the different samples bore to the weight of topped cane, and also the percentage the recoverable sucrose in different joints bears to the recoverable sucrose in the cane.

Joint No.	Weight	Per Cent	Total Sucrose	Recoverable Sucrose	Per Cent Recoverable
Stalks	52.25 lbs.	100	8.10 lbs.		
1	2.75	5.26	0.38	0.32	4.0
2	2.50	4.78	.30	.23	2.8
3	2.30	4.40	.23	.16	2.0
4	2.05	3.92	.15	.09	1.1

The amount of recoverable sugar decreases very rapidly in the succeeding portions of cane examined; nevertheless the highest joint examined (No. 4 in the illustration) contains juice capable of at least as high a recovery as No. 2 massecuite. In this case the recoverable sugar in this joint amounted to over 1% of the recoverable sugar in the cane. From a manufacturing standpoint such material as in joint No. 4 is valuable, though the extra recovery is not net gain, for there are harvesting and transportation charges also to be assessed against it.

The above investigation covers but a single case, and that rather incompletely, for it would be desirable to also have the analyses of joints Nos. 5 and 6. When this experiment was started it was expected that data on joints 1 to 4 would cover all information desired.

While this work can only be considered as preliminary, the calculations show these upper joints to be more valuable than they are usually considered. The writer believes it most desirable to investigate this subject thoroughly, particularly as the "last weathered joint" as described above appears to furnish a satisfactory reference point for such an investigation.

Bud Selection and Increased Yields.

By A. D. Shamel.

A very striking instance of the importance of bud selection as a means for increasing crop yields has recently come to the writer's attention. It is one of a constantly increasing number of illustrations which demonstrate and prove beyond all question of doubt the practical value of bud selection work for increasing and improving the yield of all plants which are propagated vegetatively.

The Canadian Agricultural Experiment Station began many years ago a variety test of apples at the Central Experiment Farm, Ottawa. The variety orchard contained a few trees each of a large number of varieties. The purpose of the experiment was to determine whether or not any of the varieties tried would be adapted for commercial apple production in eastern Canada.

In 1906 individual tree records of yields of production were begun in the variety orchard as a means for securing definite evidence as to the value, if any, of the varieties for commercial propagation. The Wealthy variety was found to be the only one which seemed to possess the essential qualifications for commercial production. Of the trees in the orchard of this variety, three were found to have characteristic yielding habits.

The three Wealthy trees were normal, healthy, and possessed the same vegetative and fruit strain characteristics. As a result of eight years of individual tree performance records it was found that one of them produced comparatively high yields, one characteristically regular annual yields, and one consistently low yields. In other words, of the three Wealthy trees one produced the greatest total crop, one a somewhat lighter yield than the heaviest producer but more regular crops, while the third produced a low total yield. The total yields of the three Wealthy trees for a period of eight years was as follows:

Heaviest yielding	104¾	gallons *
Regular yielding	78¾	gallons
Poorest yielding	41	gallons

* The unit of measurement used in these performance records was the English dry gallon which contains one-eighth of a bushel.

It should be borne in mind that there were no apparent strain differences in the three Wealthy trees. The only difference observed, except yield, was the somewhat smaller size of the low yielding tree. The foliage and fruit characteristics were the same so far as anyone could see them.

In 1906 scions were taken from each of the three parent Wealthy trees. The scions from the high yielding tree were root grafted upon stock which had been carefully selected as to size and other physical characteristics. The scions from the most regular bearing tree were similarly root grafted to those of the high yielding tree. The scions from the low yielding tree were root grafted in the same way as those from the other parent trees. Twenty-five scions from each tree were root grafted and the whole lot set out on as uniform land as it was possible to find at the experiment station farm. These young trees constituted a progeny planting. The purpose of this progeny test was to discover whether or not the yielding power of the three parent Wealthy trees was transmitted through budding. This progeny planting arrangement is similar in some respects to the present progeny cane fields on the sugar plantations in the Hawaiian Islands.

When the writer first learned of the Canadian apple bud selection study, late in the summer of 1912, he immediately went to Ottawa in order to study the conditions at first hand. The horticulturist, W. T. Macoun, very kindly showed the writer the parent trees, the progeny planting, and all of the records in this investigation.

It was found that the parent trees were located in the variety orchard as neighboring trees, but upon rather uneven or ridged land. The question immediately arose as to whether the differences in their yields were due to differences in the local soil or environmental conditions, or were the result of inherent influences. The only way by which this question could be solved was through the progeny test.

The young progeny trees were not in full bearing at the time of the writer's visit to the Ottawa Experimental Farm. However, some differences in the behavior of the young progenies were noticed which indicated that inherent differences existed in these progenies. The progeny trees from the low yielding parent tree were smaller than those of the other progenies. The progeny trees from the two high yielding parent trees had begun to bear fruit, while those from the low yielding parent tree had not begun to produce apples. The strain characteristics of the young trees in all three progenies were the same so far as the writer or his host could discover.

In the December, 1921, issue of Scientific Agriculture, the official organ of the Canadian Society of Technical Agriculturists, M. B. Davis, Assistant Horticulturist of the Central Experimental Farm, Ottawa, presents a report of the behavior of the progenies of the three parent Wealthy apple trees. A brief summary of this report is presented in order to show the facts in this investigation. It is not possible here to give the full details as shown in the report, but enough data will be presented to show the important discoveries of this conclusive study.

TABLE SHOWING RANK OF PARENT TREES AND RANK AND YIELD OF PROGENIES FOR A PERIOD OF NINE YEARS

Rank of Parent Trees	Rank of Progeny Trees	Yield of Progeny Trees
Heaviest yielding	Heaviest yielding	57.18 gallons
Most regular yielding ..	Most regular yielding ..	48.38 gallons
Poorest yielding	Poorest yielding	35.22 gallons

In addition to the very significant and important facts as shown in the above table, it should also be stated that the prognies differed very markedly in their ability to survive under the very adverse climatic conditions at Ottawa. This point is also of particular significance in connection with our sugar progeny work in Hawaii.

Of the original 25 trees in the progeny from the heavy yielding parent tree, 17 survived. Of the 25 progeny trees from the most regular bearing parent tree, 12 survived. Of the 25 progeny trees from the poorest yielding parent tree, 8 survived. In other words, the progenies from the most productive parent trees survived best under the stress of adverse environmental conditions.

In order to eliminate root stock influence, a second experiment was carried on during the same period as the first study. In this experiment scions from each of the three parent Wealthy trees were top-worked upon a large Russian tree. In this case all three parents were grown upon the same individual stock. Five top-worked trees were used in this experiment, the positions of the scions in each case being changed in order that on the different top-worked trees all of the progenies would have the same exposure to light, wind, etc.

The results of this progeny test were even more striking than those shown for the first or root-grafted progeny test. The differences between the yields of the progenies from the heavy producing parent trees and that of the progeny from the poor yielding parent tree were much greater than the results shown for the root grafted progeny trees.

These results, in a fruit that some horticulturists have said was an exception to the general rule in response to bud selection work, are of exceptional and valued importance to everyone interested in this work. They demonstrate undisputably the practical importance of bud selection and progeny work as a means for improving yields.

In sugar cane the number of stalks in a stool may be roughly compared to the number of fruit bearing branches in the apple trees in the experiment just described. In other words, in both cases it is a question of quantity. The apple study shows that quantity of fruit is an inherent character. The writer believes that in sugar cane the quantity of stalks in a stool, or the amount of sugar in the stalks, are inherent characters. In the studies with stool selections in sugar cane now being carried on by the Experiment Station of the Hawaiian Sugar Planters' Association there is abundant evidence to support this belief.

Furthermore, in our sugar cane bud selection studies we have found definite strain characteristics and have isolated strains in each of the varieties under investigation through bud selection. With this fact in mind and considering the wide range for the selection of parent stools, as compared with the limited number of parent apple trees to select from, may we not expect even much greater results than were found in the Canadian apple study?

Fig Trees for Hawaiian Forests.

By H. L. Lyon.

It is now quite unnecessary for us to call the attention of any agriculturist in Hawaii to the fact that our native forests are rapidly disappearing and that our watersheds are already bare in many places. It may be held a certainty that if sugar cane culture is to be continued in these Islands on the scale which it has now attained, existing forests must be rehabilitated and additional forests created, for if suitable blankets of vegetation are not maintained on our important watersheds they will fail to yield the constant supply of water which our agricultural projects demand.

Adequate protection of our native forests will serve to prolong their existence, but cannot keep them with us indefinitely. There are natural and uncontrollable factors now operating which will eventually eliminate the native forest trees, or at least reduce their numbers to such an extent that they will no longer constitute an adequate forest cover. The only method of procedure therefore by which we can hope to rehabilitate our old forests and create new forests is to plant introduced trees which will be able to thrive and spread in spite of the opposing factors which are proving too strong for our native forest trees.

All forest planting on the uplands in these Islands will be done for one of two purposes, either to secure trees for commercial timber, or to secure trees for watershed cover and the conservation of moisture. Watershed areas which must be reforested for water conservation only, are far more extensive than the areas suitable for commercial plantings. Due to the very broken condition of our watersheds it would cost more to get the timber out of most sections than it would be worth, and so it is quite out of the question from a practical standpoint to make commercial timber lots out of our watersheds. If we should once get them covered with good commercial timber, its value in conserving water would be so great that we could not afford to cut it off, denuding our watersheds and jeopardizing our water supply. The water-conserving properties of a good forest cover on our watersheds is of far greater value to us than any crop of commercial timber that we can possibly grow on these watersheds. It seems, therefore, that in selecting trees to cover our watersheds we do not need to select species fulfilling any requirements other than that they will become components of a suitable water-conserving forest.

The most casual consideration of our forestry problem will show that we cannot hope to cover all of the denuded areas by planting out the necessary

number of trees one by one. A procedure of this sort would require unlimited time, labor and money, and we cannot afford to concede any of these to our program. Our first aim therefore has been to find trees which not only promise to become suitable components of our rain-forests, but which at the same time show capabilities of being spread by natural agencies, such as wind, water, and birds. To enlist such trees in our reforestation work we have but to plant groups of each species at intervals on our watersheds, and as soon as the trees reach the fruiting stage they will be spread by natural forces without further attention from us.

In order to secure the forest conditions which we desire over all of our watersheds we must reforest areas presenting two distinct conditions: first, areas which are quite denuded of forest cover, and second, areas which still carry a decrepit native forest. In seeking trees which will be spread by natural agencies under the existing conditions we must find some trees which will spread in the open areas and other trees which will spread in the areas still partially covered by forests.

In searching for trees which fulfill all of the requirements enumerated above we have reached the conclusion that many species of the very large genus *Ficus* can be relied upon to accomplish much in the building of new forests and the revivification of the old forests on our watersheds. There are over 600 known species of *Ficus* or fig trees, which are widely distributed throughout all the tropical regions of the globe. It is most remarkable that no species of fig was a natural immigrant to these Islands, for there are many species in Central and South America and a very large number in Australia and on the Asiatic continent. Most of the progenitors of our native plants were immigrants from these continental regions and it seems remarkable that trees so well adapted to long migrations as are the figs did not become established here in early times. They did migrate to most of the tropical islands in the Pacific, and we find many species endemic in the Fijis and Samoa, while the little island of Guam is blessed with several species. It may be that they did arrive here, but that their natural reproduction and distribution was prevented by the non-arrival of the specific insects which are essential to their seed production. Had one or more species of figs become established in these Islands in early times it is safe to say that we would not have to deal with the serious forest problems which now confront us.

Seed Production and Dissemination in Ficus.

All species of *Ficus* have a very highly specialized mechanism for the production and dissemination of their seeds, but the operation of this mechanism is only possible through the assistance of certain wasps whose reproduction is intimately associated with and dependent upon the seed production of the fig plant. There is a particular species of wasp associated with each species of fig, the wasps from one species not being able to operate the seed producing mechanism of another species of fig.

The minute flowers of the fig are produced within a closed receptacle which eventually becomes the fleshy body commonly called a fig. The flowers are always unisexual, the male and female apparatus being produced in different

Fif 1. *Ficus macrophylla.* A young tree of the Moreton Bay fig growing at Puuomalei on Maui.

flowers which are in some species located in different receptacles. When male and female flowers are produced in the same receptacle they do not mature at the same time, and consequently pollenation of a female flower can be effected only by pollen coming from some other receptacle. The transfer of the pollen from one receptacle to another is accomplished by the wasps, which are in reality parasites of the fig as they breed in the fig flowers. The female flowers in a receptacle mature while the receptacle is quite small. The female fig wasps enter these small receptacles and deposit their eggs in many of the female flowers. These eggs hatch and the wasp grubs obtain their nourishment from the ovary of the flower. Eventually these grubs pupate and come out into the receptacle as mature insects. These newly emerged wasps mate while they are still in the receptacle, then the females bore their way out and migrate to young receptacles on the same tree or another tree, where they seek female flowers in which to deposit their eggs. While the female flowers in a receptacle mature at the time the wasps enter, the male flowers in the same receptacle mature when the new generation of wasps are leaving the receptacle. As the female wasps move about in the receptacle before leaving it they become covered with pollen from the recently matured male flowers and consequently when they enter a new receptacle they are covered with pollen which becomes distributed on the stigmas of many of the female flowers and brings about their fertilization. Hence while young wasps are developing in the ovaries of some of the female

flowers, seeds are developing in the ovaries of other female flowers in the same receptacle.

Under such an arrangement one might expect that in some receptacles the wasps would deposit eggs in all of the female flowers and consequently there would be no chance for seed development. The wasps may actually try to lay their eggs in all of the female flowers in a receptacle, but the fig plant insures that the insect will not succeed in this attempt by producing two types of female flowers, one with short styles and the other with long styles. In depositing its egg in a female flower a wasp thrusts its ovipositor through the stigma down the center of the style into the ovary, where it lays its egg. In a long styled flower the wasp is unable to reach the ovary and consequently deposits no egg therein. Hence wasps develop only in the ovaries of the short styled flowers, while the long styled flowers produce fig seeds.

As the tiny fig fruits, each containing a single hard seed, mature within the fleshy receptacle or fig the latter becomes soft and sweet and is greedily eaten by many birds, bats, and mammals. The germinating power of an uncrushed fig seed is not injured during its passage through the alimentary canal of bird or beast, and hence if dropped in a suitable place it may give rise to a new fig tree. Many species of *Ficus* start out in life as seedlings growing in the ground just as do the majority of forest trees, but there are also many species which prefer to begin their existence as seedlings perched upon the branches of other trees or upon old stumps. The seeds of these figs reach their elevated positions in the droppings of birds or bats which have fed upon the fruits. These perched seedlings send out long roots, which usually travel along the branches and trunk of the tree which supports them until they reach the ground. Having established connections with the soil the roots thicken up and usually fuse together laterally into a meshwork around their host, eventually encasing its trunk completely. Because of this habit of closely embracing the trunk and branches of the tree on which it has perched these figs are known as strangling figs, and in due time they actually strangle their host, but in order to do this they must replace it with a larger tree. Strangling figs may be considered objectionable in a commercial forest, for they sometimes replace a valuable timber tree with a tree of less commercial value, but in a rain-forest they are extremely valuable, for they always produce a larger tree than the one which they overcome.

It should be obvious that certain species of *Ficus* may be relied upon to accomplish much in the reforestation of our watersheds. They will not only spread spontaneously over the denuded areas, but they will become distributed through our decrepit forests and create therein a substantial element which will protect and strengthen the weaker trees which are unable to maintain themselves under existing conditions. Fig trees are notoriously hardy and thrive under abuse that would be fatal to the majority of trees. It is quite certain that live stock will never cause the death of the trees in a fig forest, and if we can induce these trees to become an important factor in our forest flora we need not fear that the temporary invasion of cattle will bring about such serious consequences as are sure to follow such an occurrence in our native forest. We do not mean to give the impression that fig trees alone may be relied upon to completely reforest our watersheds, but we do believe that they will become very

important self-distributing elements in all of our new rain-forests, even as figs now are in the rain-forests of most tropical and semi-tropical countries.

Economic Products From Fig Trees.

There is very little information to be found in literature regarding the timber and fuel value of the woods produced by the various species of *Ficus,* but such as we have found leads us to believe that as a rule these woods are soft, light and coarse-grained, and consequently of little economic value. The India rubber tree, *Ficus elastica,* yields a rubber of high quality. In the early days of the rubber industry this tree was planted on a large scale in Java for the production of rubber. As a forest tree it is one of the most desirable types which the genus *Ficus* affords. If planted extensively in our forests it might eventually become a source of revenue through the production of rubber, for the latex could be gathered without injuring the trees and it could be transported from sections from which timber could not possibly be removed.

Fig Trees Now Growing in Hawaii.

A survey of the flora of Honolulu for trees of the genus *Ficus* shows that there are twenty-two species already represented here by flowering specimens. To render these trees seed-bearing it is only necessary to introduce the fig wasps peculiar to each species. Among the twenty-two species the following can be employed to advantage in our forestry work: *F. Bengalensis, F. Benjamina, F. elastica, F. hispida, F. infectoria, F. macrophylla, F. religiosa, F. retusa, F. rubiginosa, F. Rumphii.* Attempts have already been made to introduce the wasps associated with five of the species named above, but thus far only those peculiar to the two Australian species, *F. macrophylla* and *F. rubiginosa,* have, for a certainty, become established in local trees.

The Moreton Bay Fig.

Among the several species of *Ficus* enumerated above *Ficus macrophylla,* the Moreton Bay fig of Australia, deserves special attention. It makes a splendid forest tree, attains very large dimensions, and adapts itself to a wide range of conditions. There are four fine specimens of this fig in Honolulu. One of these, which stands in Emma Square, is illustrated on the accompanying page. (Fig. 2.) Additional specimens have been located at Ewa on Oahu, at Puuomalei on Maui, and at Honomu on Hawaii. This tree is growing in California as far north as San Francisco, where it survives occasional light frosts. In Australia it is said to be very resistant to drouth, but delights in ample moisture. On the basis of this information we may reasonably conclude that this fig will thrive in Hawaii from sea-level up to an elevation of 6000 feet or more.

C. E. Pemberton, who has spent the greater part of the past year in Australia, has made a careful study of this tree, supplying us with much accurate data regarding its habits and those of the insects which are associated with it. He has consulted several eminent botanists in Australia, describing to them the uses which we plan to make of this tree, and they have enthusiastically recommended it for the very purpose which we expect it to accom-

Fig. 2. *Ficus macrophylla.* A large Moreton Bay fig standing in Emma Square in Honolulu. This tree has a spread of fully 100 feet.

plish here in Hawaii. Mr. Pemberton has sent the living fig wasps which are associated with the Moreton Bay fig to Honolulu and they have become established here, causing our local trees to produce viable seed for the first time. Mr. Pemberton also obtained and forwarded to us large quantities of seed, from which we have reared over 100,000 seedlings. These seedlings are now being planted out in groves on our watersheds in many parts of these Islands. When in a few years the resulting trees have reached the fruiting stage we shall only have to distribute the insects to our many groves, and each grove will at once become a source from which seeds will be spread by birds to the remotest parts of our watersheds.

Fig. 3. *Ficus macrophylla*. A large forest grown specimen exposed by the cutting down of the surrounding trees. For dimensions see text.

A properly matured fruit of the Moreton Bay fig is an inch or more in diameter. It has a very attractive appearance and a pleasant flavor. When the tree in Emma Square produced its first heavy crop of fruit it was visited by many people of the neighborhood, who gathered the fruits as fast as they fell from the tree. One of these collectors informed us that the fruits made excellent pies and puddings.

It has been suggested that the Moreton Bay fig may become a nuisance in pasture lands, but Dr. Maiden, Government Botanist of New South Wales, recommends that it be planted on dairy farms. Concerning this tree he writes as follows:

It will grow amongst rocks where scarcely anything else will grow, and it will stand being blown upon by fierce winds and being hacked about and otherwise ill-used. I admit that it can be put in the wrong place; but a Moreton Bay fig with plenty of room, so that it can live its life, is one of the most beautiful of trees, while its foliage and fruit are nutritious to stock, and its umbrageous head affords a grateful shade. . . .

Bearing in mind the way in which these and other native figs flourish exceedingly in the poorest soil, that cattle devour the leaves and branchlets greedily, that they will submit to persistent hacking back to an extent which will kill most other trees, it seems a matter for consideration that these trees should always be planted for shade purposes on dairy farms, and they should even be planted as a reserve of fodder in stony, sterile places where no grass will grow.

Our illustration (Figure 3) is from a small photograph of a Moreton Bay fig taken by Mr. Pemberton, who supplies the following data regarding the subject:

Ficus macrophylla. Typical forest shape when growing naturally. The surrounding forest was removed a few years ago. Height over all 232 feet, trunk to first branch 100

Fig. 4. *Ficus rubiginosa.* A large specimen of the Port Jackson fig growing by the side of the old Tantalus road.

feet, circumference 7 feet above ground 57½ feet. Photo taken from point 300 feet distant from tree.

While *Ficus macrophylla* will no doubt spread naturally to some extent in the open country, it prefers to begin its life as a seedling perched upon some other tree, and consequently we may rely upon it to spread in our dead and dying native forests, reinforcing these with strong growing trees which will eventually attain very large dimensions.

The Port Jackson Fig.

Another Australian fig which promises to become an important factor in our forests is *Ficus rubiginosa*, the so-called Port Jackson fig. Mr. Pemberton, who has made a very careful study of this tree in its native haunts, expresses the opinion that it will prove even more serviceable to us that the Moreton Bay fig. He finds that in Australia it thrives in the driest situations and young seedlings may be found establishing themselves on exposed rocky hillsides where other vegetation is unable to survive.

We know of only a single large specimen of the Port Jackson fig in Honolulu, and this occurs by the side of the old Tantalus Road among eucalyptus trees. There are also five young trees in the grounds of the Federal Experiment Station. Our attention was first called to the large tree on the slopes of Tantalus about two years ago by Mr. Lorrin Thurston, who desired to know its name and country of origin. Mr. Thurston stated that this tree had first attracted his attention by its conspicuous ability to resist drouth. He had noticed on more than one occasion when the neighboring eucalyptus trees were seriously suffering or actually dying because of drouth this tree seemed to be experiencing no inconvenience, but maintained its foliage in a thrifty, growing condition. Mr. Thurston recommended at that time that steps be taken to distribute this tree over the dry foothills of our mountains. It certainly promises to become an important component of our lower barrier forests and may also enter into plant formations at elevations up to five or six thousand feet in some sections of these Islands. This tree has the reputation of being one of the most hardy trees to be found in Australia. In addition to being very resistant to drouth, it will survive all sorts of physical abuse, as is evidenced by the record of the specimen illustrated in Figure 6.

During the early months of 1921 Mr. Pemberton gathered a very large amount of seed of the Port Jackson fig in Sydney and forwarded it to us in Honolulu. From this seed we have reared upwards of 150,000 seedlings, many of which have already been distributed for planting out on our watersheds. We still have a large number of these seedlings on hand in our nursery in Honolulu, and we most earnestly solicit the cooperation of everybody interested in the welfare of these Islands in getting these trees into the ground over as wide a range as possible in order that this species may become established and actively participate in the spontaneous reforestation of our denuded watersheds.

The Cedar Fig.

A third Australian fig which Mr. Pemberton recommends highly for use as a forest tree in Hawaii is the so-called "Cedar Fig," *Ficus Henneana*. Trees

Fig. 5. *Ficus rubiginosa.* A tree ten years old from seed growing at Childers, Queensland.

Fig. 6. *Ficus rubiginosa.* This stump was grubbed out of the ground and allowed to lie around for a week or more before being set out again. The photograph shows the growth which it had made within the first year after being placed in its present position.

of this species never grow to the large size attained by specimens of the Port Jackson and Moreton Bay figs. They are moderate sized trees of fine shape and appearance, and produce large fruits which are very palatable to humans as well as to birds and beasts. Mr. Pemberton has supplied us with quantities of seed of *Ficus Henneana,* from which we have reared a very large number of sturdy seedlings, only a few of which have as yet been distributed. They are available to anyone desiring to plant them out.

Other Australian Fig Trees.

There are over twenty species of *Ficus* growing as wild forest trees in Australia. While most of these are peculiar to Australia, a few species, such as *F. Benjamina, F. glomerata, F. hispida* and *F. retusa,* range throughout the Malay Archipelago, India and Southern China. The three species, *F. macrophylla, F. rubiginosa* and *F. Henneana,* which we have already introduced into Hawaii, are probably the best of the Australian figs for our purposes. We have obtained seeds of some of the others in small quantities, from which we have reared a few seedlings, sufficient to test out the varieties under our conditions here in Hawaii. If they prove to be trees of exceptional merit we can easily secure seed in quantity and spread the seedlings to the same extent that we are now attempting to spread the Moreton Bay and Port Jackson figs.

(To be concluded.)

Orientation of Cane Rows.

In connection with the orientation of cane rows, F. M. Anderson, Manager of Paauhau Sugar Plantation Company, has furnished us information from The Louisiana Planter, commented upon by the Australian Sugar Journal, and supplemented by certain observations which he has made at Paauhau.

From The Louisiana Planter: Orientation, Its Effect Upon Plant Life and Growth.

Orientation has been a new point in the culture of plants and much experimented with wherever efforts have been made to secure the greatest amount of heat and of sunlight for the benefit of the growing crops. In sugar cane this has been quite a special matter, and yet in Louisiana the tortuosity of the Mississippi River and adjacent streams and the general drainage of the plantation country in the alluvial lands away from the higher front lands to the lower rear lands, have compelled in nearly every instance the adoption of row planting, so that the sugar cane rows may go from higher to lower levels in order to secure the best drainage practicable. This being an accepted fact, it has perhaps been forgotten that orientation still has all of its original advantages. The sun rising in the east at its lower levels, gradually ascending until at midday in the tropics it becomes vertical, and its progress on to the western horizon gives those fields that are orientated an advantage in exposure to the sun's light and the sun's heat that is not always availed of, nor even understood.

The opinion of good cultivators of sugar cane in those countries where sugar cane is planted in rows has always varied more or less as to the distance that the rows should be apart. Rows five feet apart are scarcely wide enough apart to permit two-horse or mule cultivation. Such cultivation as can be done in fields of that kind would generally have to be done with straddling implements, or with the use of but one mule. With two mules the cultivator axle must be sufficiently high to pass over the growing crop without injury. Many years ago five feet rows were abandoned and six feet rows were adopted as the common standard, with exceptional widths of seven and even of eight feet; the more widely apart the row the greater is the range of sunshine that can be utilized. Eight feet rows have been known to produce better results than six feet rows, but perhaps there were other conditions rendering the general result not fairly comparable.

As human labor grew scarcer and the sugar crops became less remunerative, every imaginable device for weed killing has been utilized to meet the economic exigencies. One of these would be to have the least available tillable ground between the rows and thus to induce the plant to shade the ground at an early date. Sugar cane in five feet rows would shade the ground far more quickly than sugar cane in six or seven feet rows, all other conditions being equal. As the wider rows are preferable, permitting two-horse culture between the rows, our leading sugar planters have been rather loth to discontinue that kind of work, experience having shown that with our fertile soil and luxuriant growth of weeds and grasses, it is almost impossible to keep the fields clean and clear of weeds

without the turning plow, whether used in the hands of the plowman as a single implement, or whether combined with others and mounted on wheels.

As to the orientation of the cane crop in Louisiana, the merits of the method and the desirability of securing what orientation can be had are present problems that have never yet been solved, but may be in the future.

On the other hand, we find that in Czecho-Slovakia, Dr. Greisenegger has been experimenting with the question as to which beets yield the best results, those planted north and south, or those planted east and west. The experiments have been watched with considerable interest and have occurred over considerable areas in endeavors to ascertain definite data, but the problem apparently is still unsettled. Where moisture would be at a minimum, and where other conditions remained about equal, it was ascertained that in rows running from east to west the beets were of the best sugar content and produced the largest number of beet leaves, and the opposite result was obtained where the rows were planted north and south, the reverse way. A compromise was made and rows were planted running from northeast to southwest, and this showed a less sugar content than the east and west method, but with a better output than the direct north and south planting.

From The Australian Sugar Journal: Direction of Cane Rows.

Probably the direction of cane rows in the field is determined, as a rule, by questions affecting the convenience of working the land and keeping the crop clean, and without any special regard for the compass bearings of the lines. That this latter has some points worthy of consideration may be gathered from investigations relating to other crops, and in view of the known effects of sun and prevailing winds. An article in a recent issue of The Louisiana Planter deals broadly with this subject. On the banks of the Mississippi it is found necessary to plant in such directions as to permit of the cane rows running from higher to lower levels, thus securing the best possible drainage. There is also the question of the sun's rays, it being a recognized fact that light and heat are of prime importance in the growth of sugar. It is admitted that the "orientation of the cane crop in Louisiana, the merits of the method, and the desirability of securing what orientation can be had, are present problems that have never yet been solved, but may be in the future." In this connection we presume that the word "Orientation" is designed to mean the arrangement of the cane rows in an east to west line.

It seems that in Czecho-Slovakia experiments in the growth of beets have been conducted with this question in view. According to the Planter, it appears that whenever moisture was at a minimum and where other conditions remained about equal, the beets in rows running from east to west were of the best sugar content and produced the largest number of leaves; and the opposite result was noted where the rows ran north and south. Rows arranged northeast and southwest gave a better output than the north and south rows, but inferior to that of rows planted east and west. The subject may be worthy of observation in our own cane fields of equal fertility, but differing in the direction of the rows, where this has occurred.

Observations at Paauhau.

	Area	Tons Cane per Acre	Quality Ratio	Tons Sugar per Acre
Rows running north and south	26.5	80.8	9.39	8.60
Rows running east and west	28.2	82.4	10.27	8.01

This was obtained on unirrigated land that had previously grown Yellow Caledonia variety of cane, whilst the crop referred to was D 1135 variety. The part having rows running east and west would be considered as having somewhat better soil and not quite so exposed to winds and draughts as the part having rows running north and south.

The results of this crop should not be interpreted to mean that all of our fields of D 1135 variety produce such tonnage, but several of them this year with this variety have exceeded fifty tons under unirrigated conditions. The quality ratio results will be tabulated from the subsequent crops of ratoons.

First Season Tasseling a Possible Benefit.

By R. M. Allen.

It is customary on most of our plantations to try to avoid tasseling as much as possible. When we see a field of young cane in heavy tassel the first season, we look on it with regret and feel that we shall suffer a loss. Based on this assumption, it is a practice on practically all irrigated plantations to cut-back in June and July. This is done at considerable expense and a decided loss in cane growth. The belief is that both are justified by the benefits resulting from the absence of first season tassels.

The results of some tests recently made at Kilauea would, however, indicate that tasseling the first season, under some conditions, is a benefit rather than a loss. In December, 1920, a very thorough count was made of tassels in a field (No. 9) of Yellow Caledonia cane that had shown unusually heavy tasseling. From these counts, which were continued for several weeks, approximately 48 per cent of the cane in this field was found to have tasseled. In December, 1921, the cane was harvested and careful weights made of the tasseled and non-tasseled sticks. Juice samples were also made from each type of stick with the following results:

	No. Sticks	Total Weight in Lbs.	Average Weight per Stick	Purity	QR.	Av. Lbs. Sugar per Stick
Tasseled Sticks	255	1,557	6.10	81.7	8.82	0.69
Non-tasseled Sticks	181	1,022	5.65	81.8	8.64	0.65
Second Season Sticks (suckers)	26	127	4.88	81.1	9.21	0.53

These results indicate that the tasseled sticks produced more cane per stick and more sugar per stick than the non-tasseled sticks. The second-season shoots or suckers were treated separately, since they would hardly be comparable to either of the other types. If these were thrown in with the non-tasseled shoots the difference in favor of tasseling would be even greater. It was found that the tasseled shoots had two or more long la-las which had continued to grow and enabled these sticks to compare favorably with the non-tasseled sticks. The method of procedure in handling this test was as follows:

All the cane in a line was cut and separated into tasseled, non-tasseled, and sucker shoots. These were bundled and weighed by means of a hand balance. Care was taken in cutting not to break the la-las. This was repeated in various parts of the field until what was thought to be an average of the field was obtained. After weighing, sticks of each type were tied together and taken to the laboratory for juice sampling. This was done with a hand mill and, in order to eliminate errors, a number of individual samples were run for each type of stick. Further juice comparisons were made of the la-la, the butt of tasseled canes without the la-la, full-tasseled sticks including the la-la, as compared with non-tasseled and sucker shoots. A total of twenty-one samples was run for these comparisons. The results are as follows:

	Brix	Sucrose	Purity	Q. R.
La-la Only	19.16	15.41	80.4	9.02
Tasseled Stick with La-la removed	18.56	15.12	81.5	9.08
Full-tasseled Stick, including La-la	19.09	15.60	81.7	8.82
Non-tasseled Stick	19.48	15.92	81.8	8.64
Second Season Shoot	18.45	14.97	81.1	9.21

Basing our calculations on these results, a field having an average of two sticks per lineal foot, or 17,400 shoots per acre, all in tassel would produce 4.0 tons of cane and .35 ton sugar more than a similar field not having tasseled. Of course, with a heavier stand the difference would become greater. There would also be an additional gain due to the growth made before cutting back. These results are based on one test only and are therefore not necessarily conclusive; but they point to a very interesting possibility and will bear further investigation in an endeavor to throw more light on the much discussed practice of cutting back. One feature of the proposition must, however, be borne in mind, namely, that the large la-las are more easily broken by the wind than the non-tasseled sticks. This might be a drawback to large la-las in windy districts.

La-la sticks being heavier on the ends also recline more and are more likely to be rat-eaten than the non-tasseled shoots. The tests reported above were made in a rat-infested area; hence an even greater difference in favor of tasseling might be expected in districts not troubled with the pest.

Kilauea, Kauai, December, 1921.

Boiling House Recoveries by the Ash Sucrose Formula.

By Raymond Elliott *and* J. C. Chapman.

A system of ash-sucrose control was run over a six weeks' period, with the idea of comparing the recoveries so obtained with the calculated S. J. M. recoveries, and with the actual recoveries. The ash determinations were made according to the H. C. A. Methods of Chemical Control, 1916, the syrup and mixed juice being run daily, the other materials weekly. The sucrose figures used are those obtained in the routine laboratory control.

The ash and sucrose values, as determined, follow:

		Syrup	No. 1 Sugar	Waste Molasses	Mixed Juice	Press Cake	M. J. Cor. for Lime and Press C.
Week ending 7/23/21	Ash	1.87	.59	9.49	.....	....	.....
	Sucrose..	53.24	96.96	30.51	.....	....	.....
	Ratio ...	.0351	.0061	.3110	.....	....	.....
Week ending 7/30/21	Ash	2.00	.66	9.71	.....	....	.....
	Sucrose..	53.38	96.96	30.64	.....	....	.....
	Ratio ...	.0375	.0068	.3169	.....	....	.....
Week ending 8/6/21	Ash	1.85	.67	10.19	.417	5.54	.420
	Sucrose..	49.64	97.01	30.65	10.57	1.38	10.54
	Ratio ...	.0373	.0069	.3325	.0395	....	.0398
Week ending 8/13/21	Ash	1.83	.58	10.41	.394	4.70	.414
	Sucrose..	51.8	96.9	30.57	10.73	1.46	10.69
	Ratio ...	.0353	.0060	.3405	.0367	....	.0381
Week ending 8/20/21	Ash	1.58	.51	9.94	.347	3.96	.369
	Sucrose..	51.01	97.08	30.60	10.60	1.55	10.56
	Ratio ...	.0310	.0052	.3242	.0328	....	.0349
Week ending 8/27/21	Ash	1.70	.69	9.53	.352	3.35	.365
	Sucrose..	51.53	97.01	30.70	10.50	1.78	10.45
	Ratio ...	.0330	.0071	.3104	.0335	....	.0349
True Average	Ash	1.81	.62	9.89	.378	4.36	.393
	Sucrose..	51.81	96.99	30.63	10.60	1.55	10.56
	Ratio ...	.0349	.0064	.3229	.0357	....	.0372

From the figures tabulated above the recoveries were calculated according to the method advanced by S. S. Peck in Vol. VII, Planters' Record. His formula follows:

$$\text{Recovery} = \frac{\text{Ash Sucrose ratio of molasses} - \text{Ash sucrose ratio of Juice}}{\text{Ash Sucrose ratio of molasses} - \text{Ash sucrose ratio of Sugar}}$$

This formula was applied upon the syrup rather than upon the clarified juice. Although the syrup in the Paauhau Mill contains the remelted low-grade

sugars, which are returned to process at the liming tank, the recoveries should be strictly comparable with the S. J. M. recoveries, which are likewise based upon the syrup.

In an effort to eliminate this possible source of error, the recovery was based upon the raw juice also after the second week. Since mineral matter is added to the mixed juice in the form of lime, and since a large quantity is removed in the press cake, this necessitated a correction for the sulfated ash value of the lime, and a determination of the ash in the press cake. The results are, perhaps, open to question, due to the fact that the press cake is not weighed, and due to the varying ash equivalent of the lime. The recoveries obtained, however, are consistent, and are closer to the actual recovery than are either the S. J. M. or the ash sucrose recoveries based upon the syrup.

The calculated recoveries follow:

Week Ending	Ash Sucrose Recovery on Syrup	S. J. M. Recovery	Ash Sucrose Recovery on Mixed Juice
7/23/21	90.49	91.08	.....
7/30/21	90.10	91.02	.....
8/ 6/21	90.66	90.76	89.90
8/13/21	91.24	90.86	90.40
8/20/21	91.95	91.93	90.69
8/27/21	91.53	91.66	90.83
True Average ..	91.00	91.28	90.27

The actual recovery in the boiling house for the six weeks, as shown on the balance sheet, was 89.91.

Another set of ash determinations was run, during the same period, to ascertain the percentages of sucrose from the different massecuites going into the sugars and molasses The same formula was used, substituting the value of the "ash sucrose ratio" of the massecuite in question for that of the juice. That is the per cent of sucrose recovered in the sugar on that in the massecuite is equal to:

$$\frac{\text{Ash Sucrose ratio of molasses} - \text{Ash Sucrose ratio of Massecuite}}{\text{Ash Sucrose ratio of molasses} - \text{Ash Sucrose ratio of Sugar}}$$

This was found to give very good results with first massecuite, but with the second and third massecuites the difficulty in obtaining representative samples of second and third sugars made this determination unfeasible.

The results obtained in this experiment would indicate that the theoretical yield, as calculated by the ash sucrose formula, checked very well with that calculated by the S. J. M. formula, especially when based upon the syrup. The use of mixed juice in this connection entails two extra ash determinations and a rather involved calculation. There could be no advantage in using the mixed juice in a mill where the remelt is not returned to process ahead of the evaporators. Syrup would be the logical material to use in such a case.

Paauhau Sugar Plantation Co.

Buffer Action of Phosphoric Acid in Hawaiian Soils.

By W. T. McGeorge.

The early conception of soil acidity or sourness involved a simple absence of sufficient base to neutralize the acidity developed during organic decomposition or that caused by lack of aeration.

More recent investigations, resulting from improved analytical methods, associate iron, aluminum, and manganese with the toxicity of acid soils, a deficiency of lime or magnesia tending to promote the solubility of the above in the soil solution. The salts of these metals, being weaker bases, are more highly hydrolyzed, increasing thereby the H ion concentration or acidity of the soil solution. In lime, then, we have an agent functioning in part as a "guard" against the introduction of toxic amounts of the salts of these metals and the accompanying acidity. Conditions conducive toward such action of lime involve, however, proper aeration as a source of carbon dioxide, this being essential to the soluble calcium bicarbonate.

In the absence of lime, we have other agents functioning in a similar manner but to a lesser degree. Among these may be included the phosphates, such action being generally referred to as a "buffer" action. That is to say, the H ion concentration suffers considerable reduction in the presence of soluble phosphate or soluble salts of other weak acids, such as acetic and carbonic, which are only slightly dissociated. While the extent to which phosphates function as such in our soils is yet an undetermined factor, the possibility is not beyond reason.

Our studies on island soils have indicated the predominance of aluminum phosphate as compared with those of iron and calcium in the order given. Does this add further indication of phosphates functioning as neutralizers for the excess of soluble iron and aluminum salts? We have data showing the presence of an excess of lime to be accompanied usually by high available phosphate; for example, the Kau section of Hawaii and the Puuloa and Ewa districts on Oahu. Theoretically in such cases we would anticipate just such conditions to exist, namely, lower acidity, less hydrolyzable salts of aluminum, iron and manganese, and high available phosphoric acid. Furthermore our data indicate low lime content and its accompanying higher acidity is associated with low available phosphoric acid and theoretically the environment conducive toward the presence of the hydrolyzable salts noted above. In such cases it is not unreasonable to assume phosphoric acid functioning as a buffer, as numerous instances have been noted in our soils of similar total phosphoric acid content but widely varying available phosphoric acid.

The availability of phosphoric acid in virgin Hawaiian soils is notably increased by cultivation (aeration), fertilization, and other tillage practices. It is possible to explain this on the basis of a stimulation of the buffer action of calcium bicarbonate on the introduction of carbon dioxide into the soil atmosphere through aeration. Thus are thrown out of solution the elements standing higher in the electromotive series whose phosphates (hydrated) are less soluble and less easily attacked by the agents of solution. Response to phosphate fertilization on the virgin soils of the Islands has been noted in numerous cases.

A summary of forty-seven phosphate experiments harvested by the Station agriculturists showed only fourteen instances in which a response was obtained. These were principally on the mauka lands of Oahu and Kauai. The mauka lands are almost invariably low in lime as compared with the makai, and usually more acid.

It has been noted further that the subsoil is markedly and almost uniformly lower in available phosphoric acid than the corresponding top soil. Here again we have a lower lime content and as shown by its solubility less present as carbonate. There is also less aeration, higher acidity, and other factors conducive toward the conversion of the hydrates of aluminum and iron into their soluble salts. From the foregoing it is probable that in our subsoils and virgin top soils, deficient in lime, phosphoric acid functions in part as a neutralizer for soluble iron and aluminum salts. There results from the above processes an excess of the insoluble phosphates (hydrated) of iron and aluminum as shown by our soil analyses. It is further evident that the more consistent response to phosphoric acid on the virgin soils may be due in part to a reaction with the iron and aluminum salts. This is further indicated in the general observation of an increase in available phosphoric acid with cultivation on the Island types.

Notes on Some Enemies of the Nut Grass in the Philippines.

By Francis X. Williams.

The nut grass, *Cyperus rotundus* L., is one of the best known and most obnoxious of tropical sedges. It is certainly a very familiar species in the Australian, Hawaiian and Philippine cane fields.

The name nut grass is probably used because the root-like stems springing from the solid bulbous base of the sedge normally bear hard ovoid tubers, each capable of producing another plant. It is this habit of reproduction, well below the surface of the ground, that makes the eradication of nut grass so difficult, for, whereas a thorough cultivation of the soil will rid it for some time to come of various weeds and grasses, *Cyperus rotundus* will be about the first to spring up and thrust out its handsome but unwelcome leaves.

While this sedge has its enemies, I found that on the whole it was but little affected by them. The time devoted to the nut-grass problem, however, was short and so the observations are of an incomplete nature.

One or more species of fungus, one mealy bug, one weevil, and two or three species of moth larvae were observed attacking the plant.

The fungus is a species of rust, determined by O. A. Reinking as *Puccinea* sp., and characterized in its later stages, on the upper side of the leaf, by roundish or oblong, pale yellow spots with a brown center. Below, the brown spots are oblong pustules which, before they burst, suggest an armored scale-insect of some sort. In time these spots become more extensive, and the tip of the leaf

is the first to brown up and wither. This fungus is conspicuous among nut grass, but does not appear to be very effective. In addition, a yellowing of the leaves, with or without spots, is common in this sedge.

The mealy bug is rather a small species that works at or near the base of the leaf-sheaths and even on the bulbous portion below ground. Locally it may be quite abundant. During November, 1920, when the heavy rains had already fallen, I found what appeared to be this species occurring rather sparsely underground on the bulb. The next search for the mealy bug was in June and July, 1921, or at the commencement of the rains. Then no specimens were found on the bulb, but all were at the base of the plant between leaf bases. Many of the insects were young. A brief search among grasses mixed in with the *Cyperus* brought to light at the base of the stems of Cogon, *Imperata cylindrica,* var. *koenigii,* a very similar mealy bug.

I have found no coccid of the genus *Antonina,* such as was observed in Australia by F. Muir, attacking nut grass.

The weevil appears to be a little more plentiful than the moth borers, though none are abundant. It is quite a small insect, whose footless grubs work into the bulb from above and kill the plant. The effect is shown in the central leaves, which die early and shrivel up; thus attacked plants can easily be detected. The grub pupates in the bulb. My observations on this insect were made in November and December.

The tortricid moths—there appear to be two species—each have about the same habits, and, like the weevil, were not found to be conspicuous in nut-grass areas. I do not think I have seen more than a five per cent killing of this sedge from the combined attacks of beetle and moths. The symptoms of the affected plants are very much like those affected by the weevil. If such a plant be examined, its central axis will be found hollowed to the bulb and commencing wet decay. An old attack shows externally a withering and finally the collapse of the whole plant.

The moths are of an inconspicuous brown and gray, and much smaller than the sugar cane leafroller, *Omiodes accepta* of Hawaii. I reared a few of them from larvae, but none from egg to adult. What I take to be the eggs of one of these species are deposited in a line on a *Cyperus* leaf, and slightly overlap or shingle. They are flat discs, short oblong, and less than a millimeter in length. On hatching, the young larva immediately embeds itself in the tissue of the leaf, working downwards, and eventually tunnels the axis of plant as far as the bulb, which it may even hollow out completely. Its frass is extruded in a heap against the base of the sedge. When ready to transform into a pupa, an escape aperture for the latter is bitten through the appressed leaves above, and a silken tube or cocoon spun in the stem. The pupa is about six millimeters long and is provided with proper head and abdominal armature to help work its way out of the cocoon and partly to extrude itself through the stem. There it splits and the moth is disclosed.

A small braconid wasp, resembling an *Apanteles,* attacks the caterpillar and spins a cocoon nearby.

A single diminutive tineid moth was reared in a jar containing a lot of nut grass. Its early stages were not observed.

The introduction of plant-feeding insects to destroy certain troublesome weeds or shrubs needs a very careful study. This, then, is very true of nut-grass insects. It has not been determined whether any of these would turn their attention to forage grasses, etc., and thus become pests. I can only say that at present the subject has not been studied sufficiently to cause a decision to be made in favor of or against introducing these nut-grass enemies into Hawaii.

Varieties at Honokaa.

Honokaa Sugar Co. Experiment No. 7, 1921 Crop.

This experiment is in field 18 at an elevation of 1000 feet. The cane is first ratoons, long, and was 25 months old when harvested in June this year.

The plant crop was harvested in May, 1919. From May to September, 1919, this field received no attention. A fairly thick layer of trash covered the entire experiment. This trash was not pali-palied as it was the intention to test the ability of the different varieties to come through this layer of material. The D 1135 came through the trash to an excellent stand, the Badila also came through to a good stand. The H 109 and the Caledonia were not able to come through to any extent, and the stand of these two varieties was very poor. No replanting was done.

Young second ratoons from Honokaa Experiment 7. The D 1135 is on the left and the Yellow Caledonia on the right. A close study of this photograph will show the D 1135 to have a much better stand and to be much more vigorous than the Caledonia. There has been no trouble about weed control in the D 1135, while the weeds are bad in the Caledonia.

The yields obtained for the two crops harvested are tabulated below:

Variety	Yields per Acre			
	1919 Crop		1921 Crop	
	Cane	Sugar	Cane	Sugar
D 1135	54.1	6.6	33.2	3.41
H 109	45.0	5.3	21.6	2.72
Yellow Caledonia	34.5	4.4	16.1	2.05
D 1135	55.0	6.7	36.9	3.75
Badila	38.4	4.6	27.9	3.44

In this experiment in both crops the D 1135 has been distinctly better than any of the other varieties tried.

This experiment will be carried through another crop, using the same methods.

Details of Experiment.

Object:

To compare Yellow Caledonia, H 109, D 1135 and Badila under conditions prevailing in the unirrigated sections of Hamakua.

Location:

Honokaa Sugar Co., field 18, beginning 2 lines below the Government road, and on the Honokaa side of the field road.

Crop:

First Ratoons—Yellow Caledonia, H 109, D 1135 and Badila.

Layout:

Thirty-three plots, each 1/10 acre, consisting of 6 lines, each 4½ feet wide and 161 1/3 feet long.

Plan:

10 plots Yellow Caledonia (1, 4, 7, 10, 13, 16, 19, 22, 25, 28).
12 plots D 1135 (2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 30, 32).
9 plots H 109 (3, 6, 9, 12, 15, 18, 21, 24, 27).
2 plots Badila (31, 33).
Fertilization—Uniform by plantation.

Experiment planned and laid out in 1917 by W. P. Alexander.

J. A. V.

Has Uba Cane Commercial Possibilities in Hawaii?

By H. P. Agee.

Recently we have had the opportunity of discussing Uba cane with B. E. D. Pearce of Natal. This variety is the commercial cane of Natal and is grown almost to the exclusion of all other varieties.

We showed Mr. Pearce an area of this cane which is growing at the U. S. Experiment Station, from which a considerable amount has been distributed throughout the Islands. We were interested in learning from him whether the cane which we have is actually the Uba cane of Natal. There has been and there still remains doubt as to this. The plot of cane had been ratooned several times without much fertilization or irrigation. The majority of the sticks were very thin. The range of the size of stalks found is shown in the accompanying photograph. This picture was made from cane growing at Makiki. Most of the stalks are of the smaller size. Mr. Pearce thinks that the Uba cane of Natal is very similar botanically to the one in Honolulu. The closely adhering leaf sheaths, the large quantity of flaky wax on the stalks, and the general character of the cane, all conform. Probably they have the same cane, but a better strain of it in Natal, as he believes the greater part of their cane corresponds more nearly to the larger cane in the photograph.

Uba cane is grown in Natal, we learn, because it is the only variety which is capable of producing good ratoon crops for ten or twelve years under severe drought conditions. It is also a cane that is liked there on account of its resistance to light frosts. Mr. Pearce has seen it survive within seven miles of a snowfall at the same elevation. The rainfall in Natal amounts to about thirty-five inches a year, the greater part of which falls between November and March. Severe droughts invariably occur during the summer months. Sometimes these are so serious that much of the crop is lost, even though the variety is a drought resisting one.

The agriculture of Natal, we understand, is very simple. The cane is planted in shallow furrows about four and one-half feet apart. The dry adhering leaves are not removed and the stalks are dropped as one or two running lines without being cut into short seed pieces. In general there is no fertilization and no irrigation. The fields are not replanted more than once in ten or twelve years and often longer.

In Natal, Uba cane yields better as first, second, or third ratoons than it does as plant cane. A crop of cane occupies ground for two years. Thirty or forty tons of cane is a common yield. Mr. Pearce says that one field on his plantation gave forty tons of cane per acre as eighth ratoons. Two or three cultivations suffice in ratoons. Hilling is not resorted to. Nine or ten tons of cane produce a ton of sugar, under mill work that is not the best. Uba cane planted in favorable situations, such as river bottoms, often yields sixty to eighty tons of cane. The disadvantages presented by the thin character of the sticks are offset by its other advantages. We are told that one laborer is expected to cut and load on portable track cars about one and one-third tons of cane as a day's work. That is, three men cut and load four tons. A laborer there received less than half the wages now prevailing here.

The cane grown under the name of Uba in Hawaii, showing the range in the size of stick.

In Hawaii, though we contend with drought to a considerable extent, and though the shortage of irrigation water in certain localities is a limiting factor bearing upon cane areas, this cane, with its record for long standing usefulness in Natal and Portuguese East Africa, has never been given a commercial trial here. Such a test is, however, now under way in Hamakua, where the Honokaa Sugar Company has planted several acres of the cane we have here under the name of Uba. This test will be followed with interest.

We learn from Dr. Mario Calvino that Uba cane is now attracting some attention in Cuba. In Porto Rico it has made appeal on account of its immunity to the Yellow Stripe disease. Dr. Calvino finds it an early maturing cane, "interesting to Cuba notwithstanding that it presents the serious disadvantage of being a little thin and has too much straw."

A recent article by Dr. Calvino quotes a report from Jamaica which reads to the effect that this cane was imported from Zululand to Jamaica in 1916 and has shown itself to be so promising that about 15,000 cuttings were distributed lately. They found the cane much better than they had anticipated. A footnote to Dr. Calvino's article states that recent news came from Jamaica that the cut-

tings of the Uba cane of Natal had been extended a good deal and that the variety is increasing in favor from year to year, giving less fiber and greater purity. Data are presented showing that the cane at the age of six and one-half months yields 33.2 tons per acre, there being twenty-six canes to the plant.

The following juice analyses taken from the Jamaica report are of interest:

Age of Cane in Months	Juice				
	Brix	Sucrose	Purity	Glucose	Glucose Ratio
6½	16.40	13.09	79.80	0.84	6.42
8½	15.70	12.97	82.62	0.38	2.93
9½	17.70	14.46	81.70	0.39	2.70
10½	19.90	16.84	84.62	0.39	1.84
11½	19.80	17.24	87.99	0.191	1.09

Dr. Calvino, attracted by the early maturing quality of this cane, had analyses made on his own behalf from cane grown in Cuba. From his data we take the following:*

Age of Cane		Juice			
Months	Days	Brix	Sucrose	Purity	Glucose and Salt
9	21	20.40	16.10	78.86	4.30
10	28	17.85	15.50	86.85	2.35
11	9	20.00	17.70	88.50	2.30
12	13	17.50	12.00	68.57	5.50

The Cuba station has sought a method of crossing Uba cane with varieties of better physical characteristics. At first two seedlings were obtained, crosses of the Uba cane of Natal and D 74, and in 1921 another was secured.

The Uba cane of Natal, according to Dr. Eva Mameli of the Cuba station, can function as a female in crossing. Its pollen is sterile. Recent microscopic investigations by Y. Kutsunai of cane flowers at the H. S. P. A. Experiment Station indicate the same is true of the cane we have here under the name of Uba.

We are now attempting to cross H 109 with Uba, and in this the U. S. Experiment Station has extended to us the use of the Uba growing there, their area of this cane being considerably larger than ours. As previously stated, there is question as to whether or not the cane which we have under the name of Uba is the same as the Uba of Natal.

Dr. Calvino, in his article entitled "The Uba Cane of Natal," states that as a forage crop it is better than the Japanese or Zwinga cane and is often cul-

* The poor quality of the cane after 12 months, 13 days, was said to be due to heavy rains.

tivated for this purpose. He gives tables comparing the Uba cane of Natal with "Japanese" cane. These data are not sufficiently descriptive to enable us to identify our cane either as his "Uba" or "Japanese."

Noel Deerr, in his new edition of "Cane Sugar," has the following to say under the heading "The Uba Cane":

> This cane is of peculiar interest and history. It first appears in the more recent history of the cane as one of a number imported to Mauritius from Brazil in 1869, and it is mentioned as a well-established variety in Brazil in a report appearing in the Sugar Cane for June, July, and August, 1879.
>
> In 1882 and 1883 Messrs. Daniel de Pass & Co., of Reunion, Natal, imported canes from both Mauritius and India. Among these was one bag with a damaged label on which was to be read the letters ''Uba,'' and these letters were taken to be but a part of the name of the cane, and hence arose a legend that the Uba cane represented another with a longer name containing these letters, whereas actually the correct name had been deciphered from the damaged label.
>
> More lately Barber has recognized this cane as one of the Pansahi group indigenous to Northern India; and its presence in Brazil, evidently from early times, is unexplained. The most reasonable supposition is that it was brought by the Portuguese from India, and not as the writer once suggested that it is the original Creole cane which travelled from India via the Mediterranean to the West Indies.
>
> The origin of the word Uba is to be found in Piso's description of Brazil (1658), where Viba (and elsewhere Vuba) is given as the native Brazilian term for a reed, and was used at that time as a synonym of the sugar cane. To this cane is also attached the terms of ''Japanese Cane,'' ''Kavengire'' (evidently a corruption and misapplication of Cavengerie), and in Argentina ''Bamboo de Tabandi'' and ''Sin Nombre 54.''
>
> This cane is very different from other cultivated varieties. It is only about half an inch in diameter, with internodes up to six inches long. It is of a green color, with a very heavy coating of wax, giving it a bluish bloom, and it contains an exceptional quantity of fiber, reaching up to 17 per cent. The juice afforded by it is of reasonable density and purity.
>
> The Zwinga cane, also in some cases called Japanese Cane, is similar, with the exception of a swollen node, that of the Uba being equidiametrical with the internode. The application of the term ''Japanese'' merely implies that at some time these canes travelled from India to Japan, and thence to other parts of the world.
>
> Plate X (page 80) shows the cane, as drawn from a specimen obtained in Porto Rico, with ascertained pedigree from Brazil, via Argentina.

The color plate in Noel Deerr's work is not representative of the Uba cane as grown in Natal, according to Mr. Pearce.

In The Australian Sugar Journal of January 6, 1922, we learn from a brief article headed "Uba Cane in Bundaberg District" that this cane is now grown on a commercial scale in the Fairymead Plantations. A correspondent, Horace Young, replying to an inquiry from that Journal, said:

> We are greatly pleased with this variety for black or alluvial soils. The cost of cultivation, weeding, scarifying, etc., is less than half that of any other variety we know, and though the C. C. S. is lower than some others,—averaging between 12 and 13,—still the crop is much more even, and far heavier per acre. We are fully satisfied with it for the above soils, and intend continuing to plant it largely, having no fear of its being a ''greedy feeder.'' The fact is it is a deep rooter and draws from the subsoil, and we find it yields more sugar per acre than other varieties on these soils. We do not recommend it for red or volcanic soils. It also certainly stands frost better than most varieties cultivated.

The Australian Journal concluded its article by saying although the Uba cane has been largely grown in South Africa, it has not been regarded with favor in Queensland.

Hawaii should take steps to ascertain definitely whether the commercial cane of Natal is a better strain or variety of cane than the one which we have here under the name of "Uba." If it is, its introduction should be considered, subject to such safeguards as the entomologists and plant pathologists of this Station and the Territorial Board of Agriculture and Forestry may prescribe.

Liming Cane Juices and Its Effect on Undetermined Losses

By H. F. Hadfield.*

Before entering upon the details of this paper it would be as well to hear what the general opinion is upon the effect of liming cane juices. It is generally known that raw cane juice requires the addition of some clarifying agent to precipitate the impurities before cane sugar can be satisfactorily made from it. Lime is regarded as being the best, and so far the only agent for this performance, and when mixed with cane juice and heated at about the boiling point, clarifies it in such a way that, after settling in tanks, the clear juice can be drawn off, leaving the scums at the bottoms to be further treated. Out of some six hundred clarifying agents put on the market, lime seems to be the only agent so far that reliably clarifies the juice.

It is claimed, however, by authorities that if cane juice is over-limed at high temperatures the results are detrimental to the manufacture of cane sugar; and for this reason, if some other clarifying agent could be invented to take its place without injurious effects, there is no doubt that it would be dispensed with.

Lime is therefore added solely for the purpose of clarification, and to do this right and not reap any of the injurious effects, it is claimed that it should be added to the juice until neutral, for if added until alkaline, firstly it acts on the reducing sugars, forming lime salts of organic acids which are dark colored and easily decompose, forming acid substances, causing a loss in sugar and consequently a reduction in the per cent recovered; and secondly, these lime salts retard evaporation and crystallization, and so cause a reduction in percentage recovery. All raw sugar manufacturers know this and are ever watchful.

In our factory, during the first part of the season, the undetermined losses were so great that it was evident that something unseen was happening, the cause of which had to be remedied. It was at first very puzzling to know just where these losses occurred, when positively all mechanical losses, such as entrainment, faulty scales, leaks, etc., had been checked up. One wonders if, after all, there is not a good deal of truth in the fact that the dextro-rotating gums due to high extraction were not responsible for an excess reading of sucrose in the polariscope, thus increasing the estimated sugar and consequently the

* Read at the Nineteenth Annual Meeting of the Hawaiian Chemists' Association, November 14, 1921.

undetermined losses. Offering this solution as an easy way out of a complex difficulty, and though there may be a good deal of truth in this statement, it is doubtful whether the excess reading is so great as to offer it as a conclusive cause for large undetermined losses.

In order to find the extent of these losses, it is usual to make a balance of recovery and losses, but as this entailed a good deal of work, a simpler and equally good method was adopted. As the undetermined losses governed the boiling house recovery, the following formula was used:

$$100 \times \frac{\text{Tons Polarization in Sugar bagged}}{\text{Tons Polarization in Mixed Juice}}$$

This approximate Boiling House Recovery, in conjunction with the amount of low grade massecuite and syrup on hand, in which the sugar can be easily estimated each week, furnished a very quick means of control.

It is logical to suppose that if large losses are occurring which are not mechanical, inversion caused by deterioration of juice may be their causes. It was therefore determined to correct any acidity in the juices by adding extra lime at the scales, the presses, and at the re-settling tanks. It was essential, however, beforehand to find some method of improving the drying qualities of the low-grades, in order to overcome any viscosity or foaming of massecuites which might occur during over-liming.

An iron flume-shaped mixer was made with rounded bottom, opened at one end, 18 feet long, 24 inches wide, and 18 inches deep, inside of which ran a 2 inch square shaft, having fastened to it and staggered 14 blades 7½ inches long and 2 inches wide. The whole was driven by means of a sprocket wheel and chain at a speed of 12 R. P. M., and attached to the counter-shaft from the low-grade machines. This replaced the unreliable Scroll-mixer over the low-grade machines, and prepared the massecuite by mixing it with a hot stream of final molasses at 60° C., thoroughly breaking its viscosity and diluting it down to about 93 Brix. This method proved very successful, and increased the drying considerably, not affecting in the least the gravity purity of the molasses.

Having successfully put in operation a machine which would overcome any difficulty that might arise through over-liming, and also gained a quick figure for control purposes, preparations were made to conduct and watch the results of over-liming without fear of jeopardizing the speed of drying. As it was intended to run the whole factory as alkaline as possible in order to suppress any inversion, pipes were laid from the main lime pipe line to the presses and re-settling tanks.

The juice and mud at these different stations were always kept alkaline. Also the sweet-water from the presses, and as this was used as maceration on the mills, it formed the basis of an experiment described later on liming of mills. Additional amounts of lime over and above the usual necessary for clarification were added to the juice till it became dark in color and decidedly alkaline; soda-ash added to the seed till alkaline, to the low-grade massecuite during boiling, and with the final molasses being mixed with low-grade massecuite as a dilutant. Thus it was endeavored to keep all juices, syrups, and massecuites

alkaline, though in the last case we were never able to drop an alkaline low-grade massecuite.

The results obtained by running an alkaline juice were very marked. The total recovery increased 5%; the undetermined losses decreased from 4.0 to 0.7, showing that something important had been accomplished. Over-liming caused no caking of sugar in storage, no extra scale in evaporators; there was no need of adding phosphoric acid as there did not seem to be any harm done. The viscosity of the low-grade massecuite remained unchanged, no foaming of massecuite in cooling tanks.

In fact the only drawback seemed to be that the pans boiled a little slower than usual, though by so doing a harder grain was made, an important factor where low-grades are subjected to water or thin final molasses for diluting purposes before drying.

With alkaline juices the advent of *Leuconostoc* was to be expected, and the pipes and tanks between the scales and heaters were filled with it; sometimes ten or twelve sugar bags full would be washed out. There seemed no cause for alarm, however, as the heater pump kept going in spite of it. The pump, in fact, had a tendency to break it up, for upon examining the mud cake small pieces of *Leuconostoc* were to be found well distributed and intermingled with the mud.

The total lime was increased from 1.06 lbs. to 1.89 lbs. per ton of cane, and contrary to what has been already stated with regard to over-liming, the recovery of sugar increased. Lime has therefore not been used solely as a clarifying agent, but for an entirely different purpose, that of actually increasing the output of sugar by stopping decomposition of juice during its further process of manufacture, and after clarification had been accomplished.

The following table shows the progress made during each period by the addition of lime:

	1st Period	2nd Period	3rd Period	4th Period	5th Period
Juice Limed to Litmus	Neutrality	Alkalinity	Alkalinity	Alkalinity	Alkalinity
Pounds Lime per Ton Cane	1.06	1.34	1.45	1.54	1.89
Total Recovery	87.67	91.846	92.158	91.235	92.6
Boiling-house Recovery	89.09	93.3	93.5	92.66	94.07
Undetermined Losses	4.19	0.718	0.758	1.064	0.7
First Mill Juice Purity	87.4	88.4	87.6	86.45	87.0
Mixed Juice Purity	85.44	86.0	85.73	85.34	85.35
Clarified Juice Purity	86.0	86.3	87.4	86.66	86.5
Syrup Purity	87.0	88.0	87.9	86.54	86.9
Gravity Purity Final Molasses	35.42	36.6	36.9	37.1	38.12
Apparent Purity Final Molasses	30.0	34.0	34.0	34.0	34.0
% Ash in Sugar	0.41	0.55	0.59	0.52	0.63
% Ash in Final Molasses	8.04	8.62	8.3	8.39	9.05
Low-grade Mc. per Ton Cane	0.84	0.84	0.79	0.89	0.93
% Pol. in Cane	12.59	12.78	12.9	13.0	12.92
Stoppages in hours	23.55	54.50	25.0	82.45	74.25

The table shows plainly that by the increase of lime there was an increase in recovery, a decrease in undetermined losses, an increase in gravity purity of final molasses, with a corresponding increase in apparent purity, an increase in the ash both in sugar and in final molasses. It also shows that the decrease in recovery during the 4th period may be due to the fact that the stoppages increased to 82 hours, and in spite of an alkaline juice, losses due to inversion were going on.

It is astonishing how quickly juice will deteriorate, and if left undisturbed bubbles may be seen rising to the surface, showing that the bottom begins fermenting first. A case in point is where a continuous flow of hot juice is allowed to run over from one tank to another during the whole week. If the bottoms are not agitated large losses may result. It is important, therefore, that all such tanks either be emptied and washed every twenty-four hours, or eliminated altogether.

Liming at the Mills: Where compound maceration is practiced and intermediate carriers are continually transporting bagasse from mill to mill, and cush-cush carriers cleaning juice screens, one cannot help being impressed with the acrid smell due to acidity. Where this is occurring it is usual to suppose that decomposition is going on. It was with the idea of correcting this acidity, and hence any loss which might be occurring, that lime was added on to the mills as an experiment. Considering that an alkaline sweet-water was already added as maceration it was thought that an additional amount of lime might sweeten the last mill juices to such an extent that, in being pumped back over to the other mills, the whole system would become alkaline. It proved a failure, however, on account of most of the lime being carried over with the bagasse to the furnaces, slippage of last mill, and to the fact that twice as much was being used as usual, and even though the fields eventually recovered it, the process was not looked upon as successful.

After two weeks' experiments, a better method was evolved. Bearing in mind a twelve-roller mill and a compound system of maceration in vogue, a tank was erected at an elevation, into which milk of lime of under forty Brix density was pumped. From this tank a thin stream of lime was allowed to run by gravitation into the third mill juice receiving tank until the juice became alkaline. From here in the course of maceration it was pumped into the bagasse as it emerges from the first mill, giving it that characteristic yellow color. This strongly alkaline bagasse undergoes pressure at the second mill, its alkaline juice joining the unlimed first mill juice at the mixed juice tank, from which it is pumped to the scales in the boiling house. The alkaline bagasse emerging from the second mill is macerated with the alkaline juice from the fourth mill and runs into the third mill juice tank, where the stream of lime from the elevated tank mixes with it. The alkaline bagasse from the third mill is macerated with the alkaline sweet-water from the presses and after being pressed by the fourth mill, leaves it with practically no lime to speak of, due probably to the fact that the lime had a better chance of being pressed out of the bagasse in passing under the three sets of mills.

For purposes of control, the mixed juice going into the boiling house was kept acid. It remained, therefore, simply to set the stream of lime so that all the alkaline juices from the second, third, and fourth mills were not sufficient to make the whole mixed juice alkaline. This was done, as it was found more expedient to control the liming of the juices entering the boiling house at the scales, for, firstly, once the stream of lime was set at a certain rate it required no further attention; whereas had the control been conducted at the mills, extra help would have been required in addition to the scale boy, who controls the liming under ordinary conditions; and secondly, in analyzing a sample of raw juice first in its usual acid condition, and when it was alkaline by the addition of lime, it was found that there was a marked decrease in purities in the alkaline juice. For purposes of control, therefore, it was evident that an alkaline mixed juice sample would be in error.

As a result of this process, all sliminess, acrid smells, and sourness were remedied. The rolls took on a polished appearance, due to a slight slippage, though so far not to such an extent as to interfere with the feeding or render it impracticable.

This process of liming the mills is by no means new, as it is practiced in other sugar growing countries; control of the lime, however, is done at the mills. The method is simple and well worth recommending for trial. There seems no doubt that a certain amount of deterioration must be going on during the process of compound maceration. How much so far has not been estimated. Any loss that might be occurring, however, is not accounted for when juices are analyzed for the purpose of calculating the estimated sugar entering the mill and boiling house. For instance, suppose by analysis we find that the sugar entering the boiling house is 99 tons for the twenty-four hours, and that there is a loss of one ton in the bagasse. We are accustomed to assume that these two amounts added together of 100 tons, furnishes the amount of sugar coming into the mill. If there is a loss during the passage from the first to the last mills, as undoubtedly there is, it seems logical to suppose that this loss, however small, should be accounted for. Let us suppose it to be one ton; should not the estimated sugar entering the mill be 101 tons and not 100?

The mills at this company have always shown a small difference between the purities of the crusher and mixed juice, owing to the first mill being included, and possibly to the fact that the mills, being built on a grade, need no intermediate carriers and hence less souring is going on. During 1920 this difference was 2.2. During 1921, before liming at the mills commenced, it was 1.77, but after liming it decreased to 1.41. Whether this smaller difference was due to liming remains to be proved.

Clarification: Liming on the mills did not show any perceptible improvement in clarification, though where poor clarification is the rule a difference might be noticed. It is claimed that by this process clarification takes place as it were in the juice mixed with the bagasse, the impurities being carried into the fire room with the bagasse and not into the boiling house, thus relieving the juice of a certain amount of impurities. Heavier liming of juices at the scales resulted in a much darker colored clarified juice. As this darkness is usually

an indication of over-heated, over-limed juice, it should be reduced as much as possible. With this in view the temperature of the heater was brought down to 190° Fhr. Experiments on heater temperature during 1919 resulted in the juice settling very much slower when the temperature was reduced down to 190° Fhr. But considering that almost twice as much lime was now being added to the juice, it was thought that a temperature of 190° might be used with impunity. This deduction proved correct to a certain degree, and reduced the dark color to a clear, light one, without interfering with the rate of settling. Previously an alkaline juice could be easily detected without the aid of litmus paper by its darkness; since reducing the temperature to 190° the juice is clear, though distinctly alkaline.

During this experiment there was a marked increase in trash in the fire room. Whether this was due to the fact that less steam was being used at the heaters remains a question.

In referring back again to the table, it will be seen that the amount of lime added to the juice increased from 1.06 lbs. per ton cane to 1.891 lbs. The total recovery, after this addition, increased from 87.67%, when a neutral juice and no lime was used at the presses or re-settling tanks, to 92.6%, or an increase of 5%.

The foregoing experiments are well worth further trial. They may show that the fear of adding too much lime is unfounded; that by the addition of almost twice as much higher recoveries may result; that there is no cause for fear in over-liming if the temperature at the heater is kept down to 190° Fhr.; that boiling point at the heater is harmful; that by decreasing this temperature there will be an increase in trash; that the gravity purity of final molasses will be higher; that liming on the mills reduces decomposition, increasing the sugar output; that the estimated sugar should be based on the sugar at the crusher, and not on the total amount received at the boiling house plus that at the last mill, neglecting to account for that which may be lost over the mills during the process of extraction.

Combating the Field Rat.

NESTING HABITS.

A biological study of the nesting habits of the field rat is included in a paper pertaining to field rats in Java.* The study deals in a large part with the rice crop and the illustration reproduced herewith shows how the field rat takes advantage of the dikes in building a house that will not become inundated. We translate the description of the rat burrows, as follows:

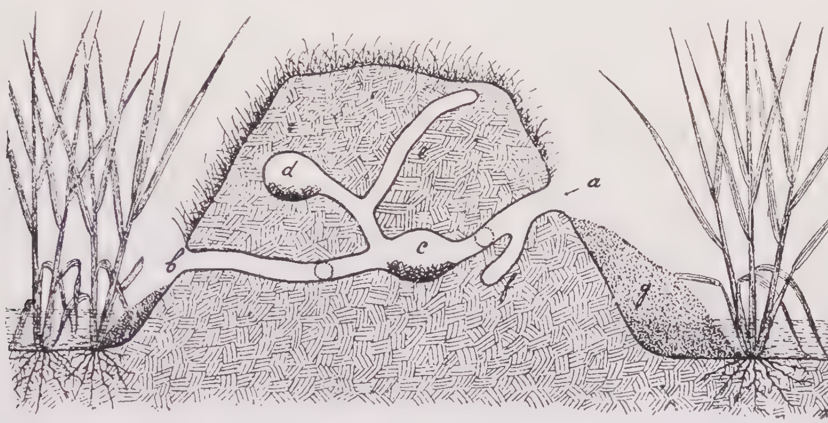


Fig. 1. A field rat hole in Java rice fields. a. Main entrance and exit. b. Secondary exit. c. Oldest nest room. d. Latest nest room. e. Emergency passage. f. Short, blind alley.

A field rat burrow (Fig. 1) consists of a more or less elaborate system of connected tunnels. In digging these tunnels the rats make good use of their strong, chisel-shaped incisive teeth; whereas their strong hind legs serve to throw the excavated soil outside. Mostly, but not always, the hole has several entrances and exits. The main entrance can be recognized immediately by the excavated crumbling soil which generally forms a cone-shaped heap under the opening. From here several of the smaller rat-trails run to the middle of the rice field. The other openings are sometimes so well hidden under all kinds of weeds that they easily escape notice. This should be kept in mind in a rat campaign.

The nest proper is made out of rice plant leaves and is a bulb-shaped widening of one of the subterranean passages (the so-called nest room), either closely under the surface or deep underground; sometimes at the beginning of a passage, other times clear at the end. For every new litter the mother rat builds a separate nest room.

Often the rat digs a tunnel running upwards, but stops just before the outside would be reached. When in danger the rat hides in this emergency passage and digs away quickly the remaining thin layer of soil and escapes. It happens very seldom that two or more rat holes are directly connected.

Characteristic is the peculiar habit of the rat mother, as a means of protecting her young ones, to plug up the main entrance, and sometimes the other openings as well: but this only for the time that the young cannot provide for themselves. The greatest care is given to the nest during the breeding period; before and after this period they serve the stray rats more as "pasanggrahans"

* Bulletin No. 16, by J. C. van der Meer Mohr. Institute for Plant Diseases, Department van Landbouw, Nijverheid en Handel. Quotations translated by W. H. Duker.

(government rest houses)—if we could call them thus—used only temporarily during their roving expeditions in times of food shortage. During the severe dry season the rats sometimes live in companies of fourteen and fifteen together in deep cracks in the soil.

Whether or not we are dealing with an occupied rat hole or one that is not can often be seen at the outside on several minor indications. For instance, the fresh footprints made in running in and out; fresh remains of food in the immediate neighborhood; and, furthermore, the before mentioned plug in the entrance. Old and unoccupied holes can quickly be recognized when the passages are filled with growing plant roots. As long as the rats live in these holes they keep them clean. The presence of mites in the nest straw points to the fact that the hole is still occupied or only recently left. The field rats do not keep food stores.

RAT DIET.

In contending with rats in rice fields much stress is laid upon the point that at the end of the harvest season, when food is scarce, active campaigns against these pests can be conducted to great advantage. It is stated that when the rice grain is scarce the rats turn to other crops, including sugar cane. This indicates, as we have thought, that rats in our fields in Hawaii may not depend on sugar cane as a sole, or even as the chief, source of diet, and that this is supplemented by other food material supplying protein.

We know of several instances where rodents have attacked cane in their search for animal food. The cane itself was not the primary object of attack, and the damage done was purely incidental. One of these cases was brought to our attention by E. L. Caum, who discovered a number of sticks of cane with large holes gnawed through the sheaths, exposing sometimes as much as a square inch of rind, and always at the nodes. In no case was the rind itself gnawed. The only explanation that can be offered is that the holes were made by mice in order to get the mealy bugs, which ordinarily congregate under the leaf sheaths at the nodes.

Another case was noticed a short time ago by Mr. Caum. In the course of experiments carried on with white rats in captivity, the animals were fed on cane only, to determine whether they could live on this limited diet. One stick given to them had been attacked by borers, and a large borer grub was then in the channel. The rats, which had had very little acquaintance with cane heretofore, immediately staged a mad scramble for that larva. After it had been consumed they gnawed out the cane joints through which the borer channel ran and made no attempt to eat any of the good cane until the partially fermented portion was completely cleaned out. In other words, they did not attempt to eat the cane as such until the last traces of animal food therein had been consumed. We know that many times borers follow rats, the holes gnawed by the rodents affording the insects easy access to the interior of the stick, but it appears that sometimes the rats might follow the borers.

RAT-CATCHING IN JAVA.

In discussing methods of combating the field rat, the Java report states:

As far as our knowledge reaches, the most effective and the simplest method is a systematic catching of the rats. The many experiments, already conducted by the Institute for Plant Diseases, with various poisons and bacteria prepara-

tions had little success. Excellent results therewith were sometimes reported from other countries, but here they never brought sufficient relief. In the meantime, the tests with poisons and poisonous gases are still continued, but for the present none of these remedies can be advocated for application on a large scale.

In the systematic drive for the rats a search is made for the rat holes and they are then hoed open; the fleeing animals are caught and killed. The only tools needed are a strong patjol (hoe) and a number of small bamboo traps. Such a bamboo trap is illustrated in Fig. 2. Any laborer can make a dozen of them in a spare hour. It is best not to make them too large, about 16 inches, with an opening not more than 2½ inches in diameter, on account of the fact that the diameter of the rat-tunnels is not much larger than that. Catching should be done in the early morning hours. To save time the rat holes should be located and marked the night before.

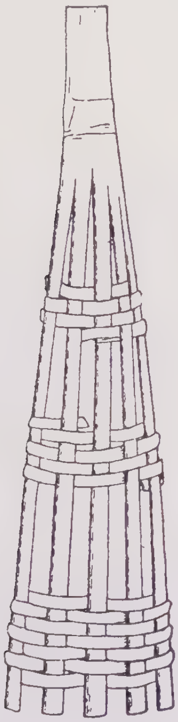


Fig. 2.
Bamboo rat trap.

First of all the nearest surrounding of the hole is carefully inspected (if necessary by cutting away all grass and weeds around the hole), to avoid chances of overlooking well-hidden tunnel openings. Furthermore, the catchers place a trap in every opening of the hole. Only now, after all these precautions are taken, may the coolies begin with their hoes. They must then try to cut open the tunnel over a short distance in a few blows. Immediately one of the helpers puts in another of the bamboo traps in the newly made opening, after locating, first, the direction of the tunnel, and then the cutting open process is continued. In this way the entire tunnel is cut open.

If it happens that the rat runs into one of the traps after the first blow, this is a stroke of luck; as a rule they hide themselves up to the last moment. However this may be, it is not advisable to quit until all tunnels are opened over the entire length. Even when finding an empty nest room, one should not give up; in many cases the mother rat, as soon as she notices danger, carries the young ones to another part of the hole. And so it may happen that several young rats may be found near the end of the tunnel, whereas the others are still in the nest room.

When a large area must be searched and when a sufficient number of men is available, it is best to divide up in groups of three or four men, each group to search a definite area and to make it rat-free; it is, of course, not advisable to have the groups too close together. In each group one man should be instructed to repair the damage done to the dikes or footpath. A well-trained gang of rat catchers working in this way can handle from six to ten rat holes per hour. Dogs can be made very useful in this work.

The question now is, when to start this catching? Are a few months of the year enough? Or should it be done all the year round? The last idea is not desirable at all, because any such measure, where a certain amount of enthusiasm is needed, slacks down when kept up too long. Besides this is not necessary.

The report then refers to the curve drawn herewith (Fig. 4), which represents the development of a definite field rat population for any given area of ample size.

The article which we are quoting calls attention to the fact that special overseers are needed to supervise the work of rat control, and that one month after

Fig. 3. Laborers in Java hoeing open a rat tunnel. The bamboo traps are set in the openings of the burrow.

the main catch the fields are searched once more for a period of two weeks for any of the rodents that may have escaped the real campaign.

Java, with its cheap and abundant labor supply, can adopt many measures which we cannot, and at first reading of the Java methods they seemed to be inapplicable to our problems. We have since been told by L. D. Larsen, Manager of Kilauea Sugar Plantation Company, who offers a bounty to his laborers for each rat that may be killed, that many of his Filipinos have adopted, on their own behalf, a system of digging out the rat burrows which differs only in degree from the one which is described for Java. The Filipinos at Kilauea, we understand, are aided in their undertakings by dogs. The bamboo traps here described have not been employed.

BURROWS IN HAWAII.

Before we had had the benefit of seeing the Java report, we undertook a little investigation to learn something of the nesting habits of the Hawaiian field rats. This work was in cooperation with the Honokaa Sugar Company. We were represented by Fred Hansson, whose report is presented in abridged form as follows:

The rats live mostly in burrows made in the ground. It is not often that any piles of soil are found outside the entrances to the burrows.* This seems to indicate that the rats make their burrows by pushing through the soil like a mole.

* This differs from the findings in Java previously quoted.

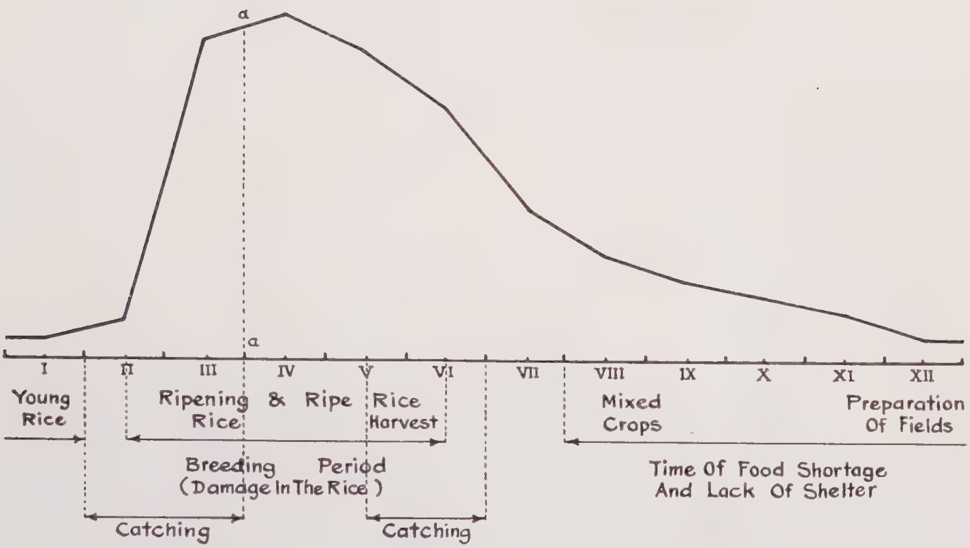


Fig. 4. This curve shows the rise and fall of the rat population under the conditions of the Java rice fields, and while such conditions are altogether different from Hawaiian cane fields, the curve is presented here to show the possibilities of biological studies which may result even under our conditions in showing what time of year is best suited for effective work of rat destruction.

The rising of the curve stands for the increase of the rat population in the breeding season; the gradual decline shows that this same rat population decreases due to a number of causes.

Another fact that bears out this theory is that the sides of these burrows are hard and tightly packed and easy to follow, while the surrounding soil is qute loose.

The rats like to make their homes where the subsoil is 18 inches or more below the surface. They push through the upper soil and make their nests at the junction of this and the subsoil, where the latter is not more than 24 inches below the surface. This lower soil is much harder than the surface soil and they do not dig into it very much. Wherever the surface soil is only 10 to 12 inches deep the rats do not make any burrows, but just go down to the subsoil and then stop. During our investigations we found several such holes.

There are always at least two entrances to the nest. Their burrows or tunnels vary greatly in length and the entrances are often five or more feet apart. In the gulches the rats live mostly in the rock piles or under boulders. A number of the burrows which had been treated with carbon bi-sulphide or cyanogen were dug out with pick and shovel. The sketches accompanying this report show the general types of arrangement of the tunnels and nests. It was found that the plan of the burrows varies with the location. It was noted that the entrances were nearly always located on the mauka side of the furrow. This was probably to avoid flooding the nest with rain waters.

The rats like to travel under cover. We found quite a number of tunnel-like places in the cane trash which showed signs of travel. They zig-zagged around and indicate that the rats stay hid as much as possible. After the cane had been cut, piled beside the flume and left over night, some of the rats would seek cover there. It is due to this habit that many were caught and killed by the dogs of the men who flumed the cane. One dog alone in one day killed twenty rats that had sought cover in the piled cane. Many rats are killed in this way during the course of a year.

The accompanying diagram (Fig. 5) shows the nesting habits of the Hawaiian field rats. An interesting point of difference is that we fail to find the blind tunnel described in the Java article.

POISONING EXPERIMENTS.

Gas.

Experiments were made bearing upon the possibility of poisoning rats in their burrows, after the practice commonly employed in contending with the ground squirrel in California. In connection with this work we had the benefit of the experience of G. R. Stewart, who has participated in work of this character.

The openings of the rat burrows, quite in contrast with those of the ground squirrel, proved to be very difficult to find, and until this obstacle is overcome, as perhaps it might be by the use of dogs, the possibilities of using poison gases in this way are not promising.

Our experiments were confined to eighteen burrows, all of which were found upon excavation to be empty. Mr. Hansson contends that rats enter the cane field after the stalk is well formed, say six feet long, and that it would be futile to gas the holes that might be found when the field is finally cleared of the crop.

A number of holes were gassed with carbon bi-sulphide and cyanogen. Most of them were treated the morning following the firing of the fields. In all cases the burrows were found empty. This clearly shows the rapidity with which the rats move to other areas.

Poisoned Barley.

The practice of the plantation in employing poisoned barley (the commercial preparation purchased in California, having strychnine as the toxic principle) has no doubt been effective in reducing the rat population. We learn from the California authorities that this barley is prepared specially for ground squirrels, which, in carrying the grain in the cheek pouch, absorb strychnine from the thin coat on the outside of the grain. This poison, thus absorbed, is said to be several times as effective as it would be if eaten and absorbed through the digestive channels.

The plantation has called our attention to poison grain that has freely sprouted in the field containers. It is claimed that this poisoned barley loses its toxic effect after exposure to moisture for a matter of fifteen days and that it is difficult to protect it from moisture under field conditions.

Miscellaneous Poisons.

An account of trials with other poisons and baits at Honokaa is given by Mr. Hansson as follows:

Squills, either in the powdered or liquid extract form, mixed with various baits, has been used with success in investigation in England and France. It is obtained from the bulb of a plant *(Scilla Maritima)*, which is found along the shores of the Mediterranean Sea and Southern Europe. We mixed the extract of squills with an equal part of milk and soaked enough oatmeal in it to form a dough. This was eaten very readily by the rodents.

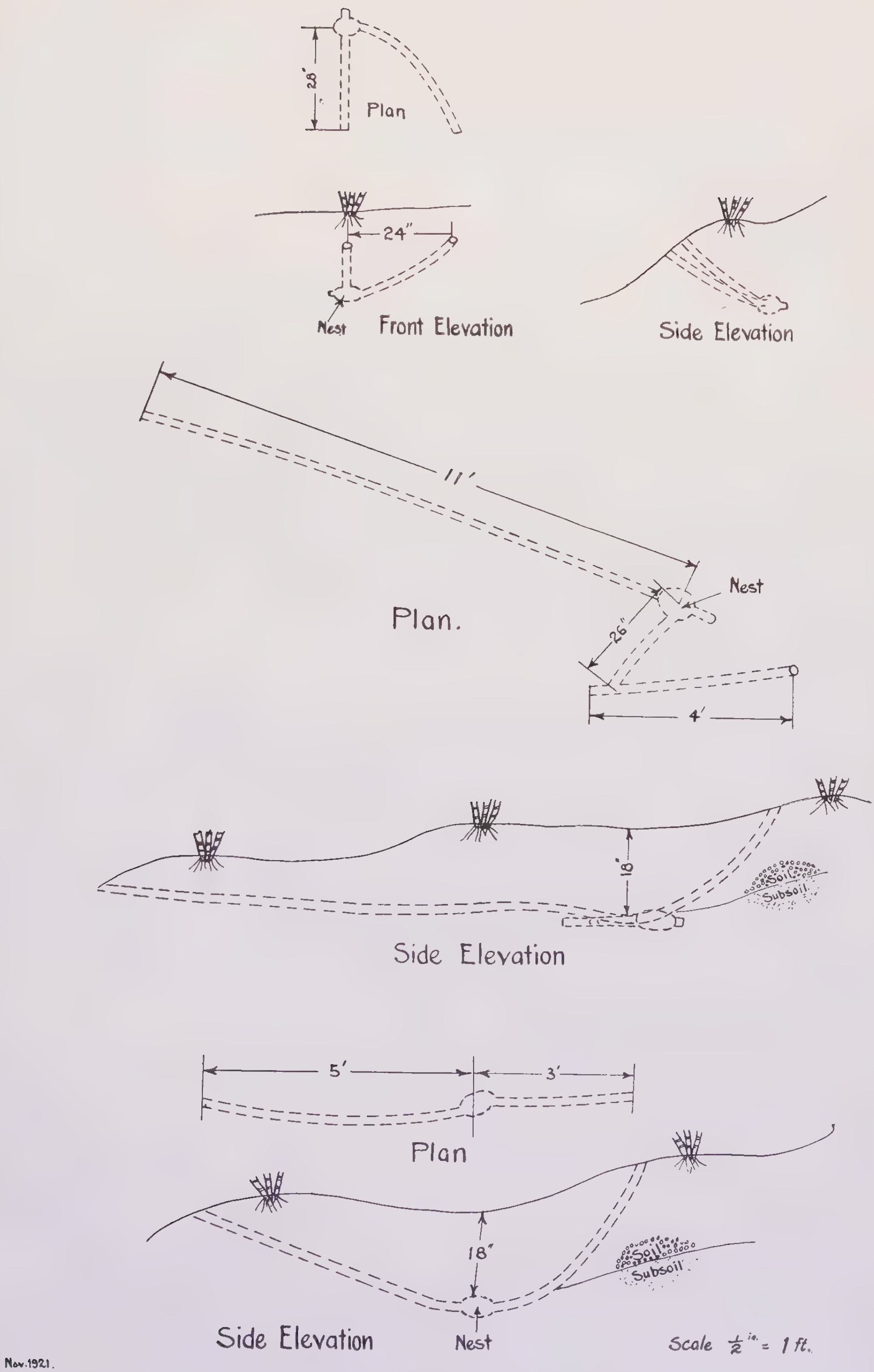


Fig. 5. Types of burrows in Hawaiian cane fields.

The powdered squills was ground up with tallow, and a portion of this mixture was combined with oatmeal, making a sort of oatmeal cake. This bait also was very palatable to the rodents and was soon consumed. We found, however, by experiments that it takes quite a long time for the squills to complete its work.

Some people suggested that molasses would make a good bait. We put out different mixtures using molasses as a bait. We mixed it with squills in both forms and also potassium cyanide. We found these materials all remained untouched.

Bi-chloride of mercury was mixed with tallow and spread on bread, but very little of this was eaten. This poison is very corrosive in its action and causes an irritation of the membranes of the mouth as soon as it touches them. It is therefore not surprising that even though the rats are fond of tallow, they did not eat this mixture.

Another poison we tried was barium carbonate mixed with various baits. This carbonate is an odorless and tasteless powder and is recommended by the U. S. Department of Agriculture. It is also used by the Indian Government in its work against rats. The plantation has tested barium carbonate more or less extensively, the present experiments being a continuation of that work. We mixed it with oatmeal; put it in cans in the dry state and placed them out in the field. This bait was eaten very freely by the rodents. Other portions were moistened with water and made into a sort of doughy mass. We placed this dough in the fields, and found that, while it was fresh, the rodents ate it very readily. It unfortunately molds rapidly and in that condition is eaten very sparingly. However, it can be molded into cakes and dried in an oven or any other convenient manner to improve its keeping qualities. This poison bait did not appear to lose its strength on standing. The whole grains of either oats or barley mix very well with barium carbonate and are very good baits. However, the rolled form of either grain appeared to be the best to use. This mixture is as easily made as are preparations with the whole grain and has the advantage that it can be molded into cakes that will not readily break apart. The best proportion appeared to be eight parts by volume of bait to one of poison.

Some other good features of barium carbonate are that it is very easily handled and is not particularly dangerous to human health or domestic animals. Although one to one and a half grains suffices to kill a rat, a chicken can take fifteen grains without injury and a dog one hundred grains. It is cheap and, unlike some of the other poisons, is partaken of very sparingly. The action of this poison starts soon after a small portion has been eaten. The rat then stops consuming the bait and goes in search of water. The poison attacks the lining of the stomach and causes a desire to drink, and for this reason is recommended as a good poison to use in buildings. We found by experimenting upon a captive rat that it took about six hours for this poison to complete its work.

TRAPPING.

Experiments with traps were also made. It was found that neither oil of rhodium nor oil of aniseed attracted rats to the baits, contrary to popular conception, and that aniseed, in fact, seemed to repel the rodents. Nothing was discovered to bear out the belief that rats shun traps which carry the scent of human handling. Many traps were found where the captives had been eaten by the mongoose. Evidence also showed that the rats attack and eat each other.

H. P. A.

Fiji Disease of Sugar Cane in the Philippine Islands.*

By Mariano G. Medalla.

Fiji disease of sugar cane, previously reported only from the Fiji Islands, New Guinea, and Australia, has been found in the Philippine Islands. It was found on the Island of Mindoro simultaneously by Professor Reinking of the College of Agriculture, University of the Philippines, and the writer. Later the disease was found in Laguna and Batangas Provinces and was there identified by Mr. H. Atherton Lee, just returned from Honolulu, where, through the kindness of Dr. H. L. Lyon of the Experiment Station, Hawaiian Sugar Planters' Association, he had the opportunity of examining preserved specimens of the disease from Fiji. There can be no question as to the identity of the disease.

The varieties Hawaii 109 and Java 247 are rather severely affected. Yellow Caledonia, Louisiana Striped and the native cane varieties Luzon White, Pampanga Red, and Cebu Purple were all affected, but at this time appear to have a slightly lesser degree of susceptibility.

In provinces where the disease is found, considerable losses have been caused on all of these varieties. One field of Yellow Caledonia plant was so severely affected that it was plowed under. In other fields, plantation managers estimate their losses at from 25 to 50 per cent, although the writer believes these losses possibly are a little over-estimated. The losses from the disease are apparently increasing from year to year. The ratoon fields seem to show more of the disease than fields of plant cane.

To minimize or entirely prevent the losses from the disease, the following measures have been taken:

(1) The Plant Quarantine Board of the Philippine Islands has issued a regulation prohibiting the movement of all cane materials from Mindoro, Laguna, and Batangas Provinces. No case of the disease has been reported as yet in Negros, the large sugar-producing island; nor has it been reported from Cebu or Mindanao. In the absence of a definite report of the disease in those islands the domestic quarantine of the affected provinces seems justified.

(2) In cooperation with plantation managers in quarantined localities, steps are being taken to furnish seed points, from disease-free fields, to planters whose fields are affected.

(3) Through the kindness of Dr. H. L. Lyon, information has been made available concerning resistant varieties. Dr. Lyon states that Badila, Rose Bamboo, and Striped Singapore varieties, although not immune, exhibit a degree of resistance to the disease. These varieties are available at the Plant Pathology laboratories and will be distributed in small amounts to planters in affected localities. [L. O. K.]

* From Phytopathology, June, 1921.

Fertilizer Practices.

We note from a recent report of the Rothamsted Experimental Station at Harpenden that as a result of their fertilizer tests they are coming to the same conclusions in regards to the methods of fertilizer applications as we have arrived at here in Hawaii: that better returns are obtained from the use of relatively large amounts of fertilizer rather than by smaller amounts, and that the time of application has a very great bearing on the results. We quote the conclusions of their report.*

The results described in previous reports show that the output from the land is much increased by the proper use of artificial fertilizers on carefully selected suitable varieties of crops. In the case of cereals, good results have been obtained by the use of spring dressings of nitrogenous manures, these being required to replace the nitrates washed out during the winter. Experiments, however, show remarkable differences in effectiveness according to the time of application. It is impossible on present data to formulate hard and fast rules, but as shown below it appears that a small dressing (1 cwt. sulphate of ammonia or less) may go fairly late, while a larger dressing should go on early.

For many years the Rothamsted data have shown that the yield of crops increases with the amount of manure supplied, but beyond a certain point the increase is no longer proportional to the added manure. In the old experiments the unit dressing was 200 pounds of ammonium salts per acre, and the dressings were increased up to 800 pounds per acre. It was then found that the effect of the last 200 pounds of fertilizer, *i. e.*, of the increase from 600 to 800 pounds was very small and unprofitable, while the first 200 pounds had proved distinctly useful. This is in accordance with the Law of Diminishing Returns. It was assumed, therefore, that the law held for light as well as heavy dressings of manure and a deduction was made, for which the evidence was rather slender, that a small dressing of manure gave the largest profit, while further dressings gave a relatively smaller return.

Recent work, however, has disturbed this view. Two hundred pounds per acre of ammonium salts is too large a unit for modern practice, hence more interest attaches to the effect of the smaller than to the larger dressings. Examination of the Broadbalk results shows that the largest return is given, not by the first dressing, but by the second.

The conditions of an experimental field are not quite those of practice, and accordingly a new experiment has been started to see if under ordinary conditions of farming the highest rate of profit is given by good rather than by small dressings of fertilizers. The results of the first year (1920) suggest that this may be so.

* Report 1918–20 with the Supplement to the "Guide to the Experimental Plots," containing yields per acre, etc.

INCREASE IN WHEAT CROP, 1920, FROM SPRING DRESSINGS OF SULPHATE OF AMMONIA AND SUPERPHOSPHATE.

	Grain—Bushels per Acre			Straw—Cwts. per Acre		
Date of application of manure	Feb. 10	March 6	May 10	Feb. 10	March 6	May 10
Single dressing	Nil.	0.9	2.7	2.7	6.9	9.4
Double dressing	7.0	...	3.7	11.7	...	12.7

While the single dressing (100 pounds sulphate of ammonia per acre) gave no appreciable increase in grain, and only a fews hundredweights of additional straw, the double dressing gave increases of no less than seven bushels of grain and twelve hundredweights of straw. Late application of the double dressing, however, was risky, giving an unhealthy straw, liable to lodge and prone to disease. [J. A. V.]

The Human Element in Power Plants.*

Human interest or personal touch has been sadly neglected in many dealings with power plants and power-plant apparatus; this is one reason why, perhaps, so many are operated as they are, why the operating force so often fails to receive the recognition accorded other workers, and why the power plant is too often a thing apart. Perhaps the engineers themselves are largely to blame for this. The work of the power plant necessarily serves to isolate its workers; the functioning of the plant is such that only those most closely in touch with its *modus operandi* appreciate and understand them. As a consequence it is left to itself because the factory or organization managements know little about it and because the power-plant personnel, as a rule, make little or no effort to make themselves or their work known.

A trip was recently made through a factory in company with the president, who prided himself upon the extent to which he had introduced the human interest or personal touch in his organization. A cafeteria and rest rooms for the employees had been provided, there was a tennis club, a mutual benefit association, group insurance, a visiting nurse and similar welfare activities to show that the employer had the interest of the employees at heart. Working conditions were good, including ample light, generous ventilation, individual lockers, shower baths, etc. A form of employees' representation had been adopted, as showing, further, that human interest and personal contact are vital phases of present-day industrialism.

After the inspection of the factory, and on the way back to the office, the president was asked why he had not shown the power plant—the heart of the establishment. He replied that he had forgotten about it; he rarely visited it, because it was hardly part of the factory proper and was so troublesome anyway.

* From Power, Vol. 54, No. 14, p. 533.

As might be surmised from the remarks made, the plant had never had much of a chance any more than had its personnel. The boiler room was dark and cramped, apparatus was run down, and the whole place looked uncomfortable. Doubtless performance was in keeping with environment. There was nowhere for the men to sit down and rest and reason things out, notwithstanding that the modern plant requires brain more than it does brawn. There was no adequate place for the men to change their clothes or wash. There was no special place to eat. There was nothing to make the plant fit for human habitation or encourage good work.

"How is it," the president was asked, "that you have carried your employees' welfare so far in your factory and yet apparently have done nothing in the same direction in your power plant?" "Oh," he said, "it is pretty difficult to do anything here, because these fellows are hard to please. They do not seem to mix with the rest of the employees, and anyway, I hardly consider this part of the plant."

This little incident holds true for numerous plants—and the more's the pity. The managment does not think; it divorces its power plant from the rest of the establishment notwithstanding that the entire works depends upon the functioning of the power plant and the loyalty of its workers.

The engineer who obtains the viewpoint of those that must pass on his suggestions is more likely to "sell" his ideas than the one who sees only his own viewpoint. There are different ways of explaining a thing, and very often the less technical it is the better. Introduce the personal element, or human interest.

Insist on being "one of the boys" when it comes to employees' welfare. If the company issues a house organ, make it a point to have brief mention of the power plant, what it is doing and who comprise the personnel. It pays to advertise. A little insistent publicity in a legitimate way, telling of the good work the men are doing, how admirably the plant is accomplishing its task and similar "human interest" propaganda will do wonders in winning the recognition that the power plant and its crew usually deserve. [W. E. S.]

The Aeroplane in Agriculture and Forestry.

That agriculture is to benefit from aeronautics is now evident from recent developments along this line. The use of the aeroplane in patrolling forest reserves on the mainland, in connection with the detection and control of forest fires, has been perfected and is now in common practise. Using aeroplanes for dropping tree seed in the reforestation of cut over timber land, we understand has been proposed, but we do not have at hand information as to whether this has been employed in practise.

The aeroplane has other uses in agriculture, one of which extends to economic entomology. An article entitled, "Spraying Trees From an Aeroplane," from the "Aerial Age," August 29, 1921, reads:

The novel experiment of spraying a grove of trees from an aeroplane, the first ever attempted in the United States, was made on August 4 over the farm of Harry A. Carver, near Troy, Ohio, to prevent further ravages of worms which have twice practically defoliated this grove of 5000 Catalpa trees. The plane, piloted by Lieut. Johan A. Macready, Air Service, and carrying E. Dormoy, McCook Field, designer, who constructed the sifter used to spray the arsenate of lead powder, flew within 20 or 25 feet of the top of the trees, releasing the powder which was carried by the wind and air currents from the ship's propeller into every part of the grove.

Treatment of trees in this manner saves much time and labor, as an aeroplane in a few minutes can do work which would require a number of men and many pump sprays several days. The effect of this experiment will be watched with interest by entomologists and forestry experts in many parts of the country, especially in the east, where a similar scourge is working havoc with many magnificent elm trees. The idea of utilizing an aeroplane for this purpose originated with C. R. Neillie, of Cleveland, who came to Troy to witness the first trial. H. A. Gossard, Chief of the State's Department of Entomology, also came to witness and assist in the experiment.

Mr. Dormoy is understood to be working on a new hopper which will simplify spraying of the powder, and McCook Field officials have indicated their willingness to cooperate with farmers and with the Department of Agriculture in combating insects and tree infection.

This experiment connects in an interesting way with the recent work of our entomologists in employing dust insecticides as a substitute for liquid sprays in leafhopper control. Experiments conducted by H. T. Osborn showed that a nicotine dust preparation had certain advantages over solutions based on the same ingredients.

It is not unreasonable to suppose that some adaptation of the method of controlling worms in Catalpa trees, with arsenate of lead, may be applied in employing a nicotine dust to control obstinate outbreaks of leafhopper, in the event that these should continue to recur. The expensive equipment required would perhaps be offset by the vast area that could be covered in a short time by aeroplane. The spraying or dusting of cane one to two years old has never been feasible and perhaps these new uses of aeroplanes offer a solution.

Dr. H. L. Lyon, George A. McEldowney, and the writer have discussed the possibility of employing aeroplanes for sowing tree seed over watersheds where the native flora is in a depleted condition. Plans for experiments in this direction are now being discussed with the Hawaiian Department of the U. S. Army and the Board of Agriculture and Forestry. H. P. A.

Clarification.

By W. R. McAllep *and* H. F. Bomonti.

Increase in Purity.

During the last few years the increase in purity from mixed juice to syrup in Hawaiian factories has been steadily decreasing. Since 1918, the average shown in the Annual Synopsis of Mill Data has decreased from 1.79 to 1.13. This investigation of clarification was begun, largely, because of the apparently poorer average results secured and because of differences of opinion as to the preferable way of conducting the clarification.

The first juices examined were from the Experiment Station plots in Honolulu. Afterwards mixed juice samples from different Oahu factories, the greater part of them, however, from Honolulu Plantation Co., were studied. Later a few samples of juice that gave trouble in factory practice on account of poor settling were secured. The juices can be divided into two fairly distinct classes, those clarifying well and on settling leaving a comparatively clear juice and those in which lime and heat failed to produce a satisfactory clarification, leaving turbid settled juice. Increases of from 2.5 to 4.0 points in apparent purity have been secured in juices of the first class. Juices of the second class have not yet been thoroughly studied. Much smaller increases in purity were secured, however, than in juices giving a satisfactory clarification.

A close estimate of the size of the possible increase in purity comparable with the Annual Synopsis figures for the actual increase cannot now be made. The juices studied were drawn from a somewhat limited area; a considerable proportion of them from a small area, and there is but little information indicating what proportion of the whole is made up of the second class of juices. Data now available, however, show the characteristics of the first class of juices at different reactions of the clarified juice and also how clear clarified juices can be secured from juices of the second class. For this reason it seems advisable to publish these data at the present time, rather than to wait till some of the details can be more thoroughly studied.

The increases in purity herein reported are comparable with increases in purity from mixed to clarified juice, rather than with increases in purity from mixed juice to syrup, ordinarily referred to when the term is used. We would note, however, that the latter ought to be larger than the increase in purity from mixed juice to clarified if the clarification, filter press work, etc., is carried on so that no deterioration or inversion takes place, because of the well-known tendency of the polarization to increase in proportion to the sucrose during clarification, evaporation and boiling.

Two major factors contribute to the increase in apparent purity from mixed to clarified juice shown by the routine chemical control. These are the mechanical and the chemical removal of solids from the juice. A third factor in heavily limed juices, is the increase of polarization in proportion to sucrose.

Mechanical Increase in Purity.

Mixed juice as it comes from the mill contains suspended matter in amounts varying with the mill equipment, the amount of soil adhering to the cane, and the thoroughness with which the juice is screened. This suspended matter varies in size from the largest particles that can pass the mill screens to colloid dispersions of ultramicroscopic dimensions. Without further discussing the classification of colloids, we consider it proper to include colloids that contribute to the mechanical increase in purity with the suspended solids because they are of sufficient size to be removed by filtration without resorting to coagulation or other means to reduce their degree of dispersion.

Though the suspended solids are not in solution they influence the solids determination. If this is made by drying, they affect it to the same extent that they would if they were in solution. If it is made with a hydrometer the effect is less, corresponding to the amount that the apparent specific gravity of the juice is increased. The latter effect will also vary according to the manipulation. If the juice is mixed immediately before determining the brix, the maximum effect will be obtained. If the juice is allowed to stand, the effect will be smaller according to how completely the suspended matter has settled when the hydrometer reading is made. The brix of a juice before clarification is then somewhat indefinite, but is always higher than the brix due to the solids actually in solution. The purity calculated from this brix will, therefore, be lower than the actual purity, or ratio of sugar to dissolved solids.

The suspended matter including all but a very small proportion of the colloids can be removed by filtration. After such filtration the brix can be considered as that due to the dissolved solids and the purity calculated from this brix, the ratio of sugar to dissolved solids. The "mechanical" increase in purity is the difference between this purity and the purity as determined on the unfiltered juice.

The "mechanical" increase in purity has been determined on a considerable number of juices in this investigation. The mixed juice samples were allowed to stand for half an hour or more and when necessary the surfaces cleaned by flooding before determining the brix. Suspended matter that had passed the mill screens was not removed. The following filtration method was used: A liter of juice was mixed with approximately 50 grams of kieselguhr and filtered over reduced pressure through a Buchner funnel prepared in the following manner: A disc of 24 mesh brass screen, 9 cm. in diameter was placed in a 15 cm. funnel and covered with a moistened, rather heavy, 12.5 cm. filter paper. When vacuum was applied, the edges of the moistened paper were drawn down forming a seal. The filtration of a liter of juice was usually complete in between one and two minutes. The filtrate was then passed through a second funnel similarly prepared, except that a hardened filter paper was used. The second filtration was usually completed in from 10 to 15 seconds. After filtration, by this method, juices are limpid and apparently free from suspended matter. When examined by the "Tyndall cone," that is a beam of light passed through the juice in a darkened room, the cone is distinctly visible and the dispersed light is polarized, indicating that this filtration does not completely remove the colloids.

The following tabulation shows the average mechanical increases in purity obtained in juices from different sources, and also a comparison with the maximum increase obtained on clarifying the unfiltered juice with lime:

TABLE I

Mill	Number of Samples	Increase in Apparent Purity		Mechanical % of Total
		Mechanical	Total	
Experiment Station	16	0.46	2.89	16%
Honolulu Plantation Company 1	7	0.97	2.96	33%
Honolulu Plantation Company 2	1	0.3	2.9	10%
Waialua	2	0.5	2.69	19%
Ewa	2	0.6	2.8	21%
Waimanalo	1	0.6	0.8	75%
Average	..	0.58	2.72	21%

The juices marked "Experiment Station" were expressed in a small three-roller mill at the Station. All other samples, with the exception of Honolulu Plantation No. 2, were mixed juice, as it was sent to the boiling house at the factories named. The sample designated Honolulu Plantation Co. No. 2 was mixed juice after passing through a 100 mesh screen.

The size of the mechanical increase in purity in juice from the different sources follows somewhat closely what might be expected from the milling and screening practice. That is, where the practice is such that large quantities of suspended matter would be expected in the juice, the increase is larger than where smaller amounts are probable. At the Experiment Station there is no screen, but the milling is very light. The cane is shredded at the Honolulu Plantation and the screen is coarse. At Waialua and Ewa the cane is rather finely divided, the milling heavy, and the screens fine. At Waimanalo the milling is light and the screen coarse. Referring to the sample marked "Honolulu Plantation Co. No. 2," it will be noted that removing the suspended solids retained on a 100 mesh screen, reduced the mechanical increase in apparent purity to one-third of the average value found in other juices from this source.

Zerban[1] found an average mechanical increase in purity of 0.45 in seven determinations. He also concludes that "the 'mechanical' side of clarification is infinitely more important than the 'chemical effect.'" The mechanical increases in purity shown in Table 1 agree reasonably well in size with those found by Zerban, with the exception of the juices from the Honolulu Plantation.

The ratio mechanical increase in purity to total increase obtained by lime, heat and filtration, appears in the last column of the table. The sample of juice from Waimanalo is the only one in which the mechanical is the larger part of the total increase. This was a juice of the second class. It did not clarify well and the total increase in purity was small. Juices from Honolulu Plantation, with an average of 33%, show the next largest percentage of mechanical to

[1] Louisiana Bulletin No. 173.

total increase. High individual samples of these juices were 38.5, 41, and 50%, respectively. All other juices listed in the tabulation show a much smaller ratio. The average of all determinations was 21%. It is probable that this figure is representative of Hawaiian conditions, though present information is too limited to justify a definite conclusion to this effect. The reason this figure differs so much from the 72% found by Deerr [2] is that in obtaining it, solids were determined with a hydrometer as in factory practice, while Deerr determined solids by drying. Comparisons of the mechanical increase in purity in experiments such as Deerr's, where the solids are determined by drying, with increases in purity shown by the ordinary control figures, where the solids are determined with a hydrometer, are misleading. The proportion that the mechanical bears to the total increase in purity shown by the control figures is less than would be inferred from such experiments.

The mechanical increase in purity cannot be regarded as a real increase in the sense that the ratio of sugar to dissolved solids has been changed. It is rather to be regarded as due to an error in the methods of analysis in the case of juice containing suspended matter, caused by the effect of this suspended matter on the solids determination. It is, of course, necessary to remove suspended matter from the juices before continuing with the manufacturing process, but when increases in purity due to chemical treatment as large as those shown in the table are secured, Zerban's conclusion that "the mechanical side of clarification is infinitely more important than the chemical effect" seems hardly justified from the standpoint of the manufacture of raw sugar.

Though the proportion of suspended matter remaining in a well clarified juice is comparatively small, all of the mechanical increase in purity will not be realized in ordinary clarification for two reasons. First, the remaining suspended matter will depress the clarified juice purity slightly. We have found a maximum difference in purity of 0.2 before and after filtering a well clarified and settled juice in the manner previously described. The average of a number of determinations is less than 0.1. Second, the suspended matter is subjected to the action of lime and heat before its removal, such action dissolving a part of the fiber. This subject has been treated in a recent article.[3] This factor will normally be larger than the first. While there is not a definite quantitative relation between the amount of suspended matter present in the mixed juice and the depression of the purity, such data as are available at present seem to indicate that the solution of suspended matter during clarification can offset from a third to a half of the mechanical increase in apparent purity.

Chemical Increase in Purity.

The chemical increase in purity in the lime defecation process is due to the precipitation of soluble solids from the juice by the action of heat and lime. Gums, proteids, phosphates and bases with the exception of alkalies are precipitated. Colloids are coagulated and settle, together with the greater part of the

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[2] Record, Vol. 19, page 50.

[3] Record, Vol. 25, No. 3.

remaining suspended matter, except the portion of the latter dissolved by the lime, the settling being facilitated by the heavy precipitate of phosphates and bases.

While much has been written on clarification, the possible increase in purity has been given minor consideration. Opinions expressed as to its size vary from one to four points, these opinions, no doubt, being influenced by the quality and composition of the juices that have come under a particular writer's observation.

This investigation of the chemical increase in purity has been directed principally toward obtaining data applicable to Hawaiian conditions regarding the effect of varying amounts of lime on the purity and determining under what conditions the maximum increase in purity can be secured. The work has been carried on in a manner approximating as nearly as practicable factory conditions, and the results expressed so as to be closely comparable with control figures. To this end the juices have been clarified in the presence of whatever suspended matter they happened to contain, reactions are referred to litmus as an indicator, and results are expressed in terms of apparent purity. The relation of increase in apparent to increase in gravity purity and the relation of litmus to phenolphthalein reaction have also been studied.

The general procedure has been to clarify liter portions of a sample of juice with different amounts of lime, to obtain a series of clarified juices preferably running past the point where the maximum increase in purity was secured. The limed juices were boiled, allowed to settle on a steam bath for an hour to an hour and a half, and filtered in the manner previously described. Analyses were made by the dry subacetate of lead method. The above procedure is the equivalent of factory practice, with the exception of the filtration. Filtration was more convenient than attempting to decant the comparatively small amounts of juice used and a higher degree of accuracy in analyses was obtainable with the disturbing effect of suspended matter eliminated. As previously noted the filtration has a slight effect only on the apparent purity of a well clarified and settled juice.

The litmus used in titrations is in the form of a sensitive non-absorbent paper [4] prepared for this purpose. The procedure was to add the standard solution to the sample in small portions till the neutral point was passed, a drop being placed on the paper after each addition. After the last addition of standard solution, the drops were shaken off, leaving a row of spots graduated in color from red to blue. The neutral point can be determined with a high degree of accuracy. The color of the solutions does not interfere. Solutions as dark as molasses can be accurately titrated by this method.

Reactions have been expressed in per cent CaO; that is, CaO equivalent to the amount of standard acid or alkali necessary for neutralization, calculated to percent on the juice. This is a method of expression that has become conventional in the beet industry. The method of expressing reactions sometimes used in the cane industry, cubic centimeters of normal acid or alkali per 100

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[4] Papier Reactif Tournesol Sensible, made by Ch. Gallois & Fils.

cubic centimeters of juice, may be converted to this standard by multiplying by .028.

At present, data for twenty clarification series are available. With one exception these juices were of the class that clarify and settle satisfactorily. Though a few samples of the other class have been secured, to date the work on such samples has been directed principally toward finding the reason for the characteristics shown by them, and but one at all complete series showing the purity at a number of different reactions is available. As the clarifications were made in the presence of suspended matter the whole of the mechanical increase in purity was not realized and the figure obtained by subtracting the mechanical from the total will be smaller than the actual chemical increase. This applies particularly to figures for gravity purity. In apparent purity the effect of not realizing the whole of the mechanical increase on the figure for chemical increase is offset to a greater or less extent by the change in the ratio of polarization to sucrose.

The following tabulations and graphs are with reference to juices that clarify satisfactorily. Table II and Figure 1 show the results of an experiment where a large increase in purity was secured. The juice was Lahaina from Honolulu Plantation Co. The low purity of this juice was due to delayed harvesting. We would note that the inspection of all available data does not indicate any apparent connection between low purities due to this cause and the size of the possible maximum increase in purity. However, if only sufficient lime is added to result in a clarified juice neutral to litmus the tendency is for the increase in purity to be very small. In this case the increase in purity at the neutral point to litmus was but little larger than was obtained by filtration alone.

TABLE II

Treatment	Reaction Litmus	Reaction Phenolphthalein	Purity		% CaO
			Apparent	Gravity	
Mixed Juice	.012 acid	.085 acid	75.52	77.54	....
Filtered	.012 "	.085 "	76.37	78.50	.030
2 cc. lime	.003 "	.069 "	76.43	78.35	.027
4 " "	.003 alk.	.050 "	76.75	78.68	.026
6 " "	.006 "	.029 "	77.53	79.49	.025
8 " "	.008 "	.012 "	78.60	80.20	.033
10 " "	.010 "	.007 "	78.90	80.43	.042
12 " "	.012 "	.005 "	79.14	80.66	....
14 " "	.013 "	.004 "	79.22	80.63	.065
16 " "	.015 "	.002 "	79.61	80.65	.081
18 " "	.017 "	0	79.86	80.92	.089
20 " "	.020 "	.003 alk.	79.14	80.20	.102

Purities and lime salts are plotted against reaction to litmus in Figure 1. The scales for purity, lime salts, and reaction to litmus are respectively at the left, right, and bottom of the graph. Figures opposite points on the apparent purity curve are for reaction to phenolphthalein. Underlined figures for reaction indicate acidity. The figures at the bottom immediately above the scale

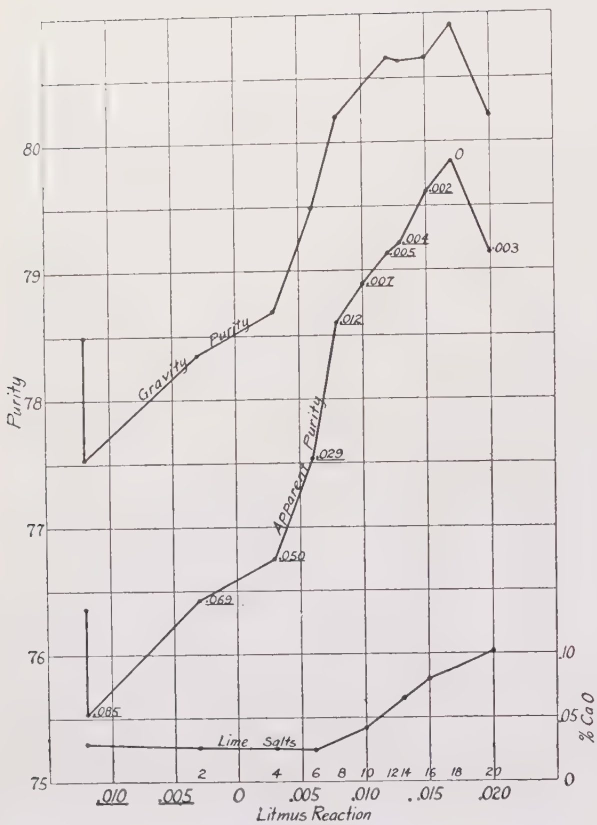

Figure 1.

for litmus reaction indicate the cubic centimeters of a 10 brix lime suspension used. Mechanical increase in purity is indicated by vertical lines joining the left of the purity curves. As noted above, the increase in purity at the neutral point to litmus is but slightly larger than the mechanical increase in purity. The steepest part of the purity curve is between neutrality and .008 alkalinity to litmus. From the latter point to phenolphthalein neutrality the curve is somewhat flattened. In this portion of the curve, comparatively large amounts of lime were required to make a small change in reaction either to litmus or phenolphthalein. The maximum increase, both in gravity and apparent purity, is at the neutral point to phenolphthalein. After this point is passed the purity curves decrease sharply. The increase in gravity and apparent purity is approximately the same to .006 alkalinity to litmus. From .006 to .008 the two curves show a slight tendency to converge. From the latter point to the neutral point to phenolphthalein this tendency is much more pronounced, and indicates that between these points some 50% of the increase in apparent purity was due to the precipitation of impurities and 50% due to a change in the ratio of polarization to sucrose. The two curves converge much more rapidly after the neutral point to phenolphthalein is passed. The increases in apparent purity in this series were: mechanical, 0.85, and total, 4.34. In gravity purity the figures were: mechanical, 0.96, and total, 3.38.

In this experiment the lime salts decreased slightly up to .006 litmus alkalinity. At .008 they were close to the original amount, increasing after this point till at the neutral point to phenolphthalein they were three times the original amount. The increase in lime salts at phenolphthalein neutrality to three times the original amount is in good agreement with other experiments on juices of the class that clarify well. The slight decrease shown in the more acid members of the series is rather exceptional.

In this experiment two points of particular interest are fairly sharply defined. These are: .008 alkalinity to litmus, corresponding to .012 acidity to

phenolphthalein, and neutrality to phenolphthalein. At close to the former point examination of the ash indicated that precipitation of phosphates and bases was finished. This was also the point where lime salts began to increase rapidly. Up to this point the change in reaction to phenolphthalein and the amount of lime used were in a definite proportion. Past this point the same amount of lime caused a much smaller change in this reaction. If purities are plotted against the amount of lime used, a definite change is noted at this point. On the acid side 1 cc. of the lime suspension used caused an increase of approximately 0.35 in both apparent and gravity purity. Between this point and neutrality to phenolphthalein the same amount of lime caused an increase of 0.12 in apparent and 0.07 in gravity purity. The neutral point to phenolphthalein is of particular significance because here the maximum increase in gravity and apparent purity was secured, and here also another marked change in the relation of gravity to apparent-purity occurred.

Table III and Figure 2 contain the data of a series on juice from H 5001 cane grown at the Experiment Station plots. This is a case where a large increase in purity was secured in juice of about average purity.

TABLE III

Treatment	Reaction Litmus	Reaction Phenol-phthalein	Apparent Purity	% CaO
Mixed Juice	.016 acid	.080 acid	83.43	.021
4 cc. Lime	0	.060 "	85.84	.025
8 " "	.006 alk.	.034 "	86.34	.025
12 " "	.010 "	.008 "	86.51	.033
16 " "	.012 "	.002 "	87.16	.038

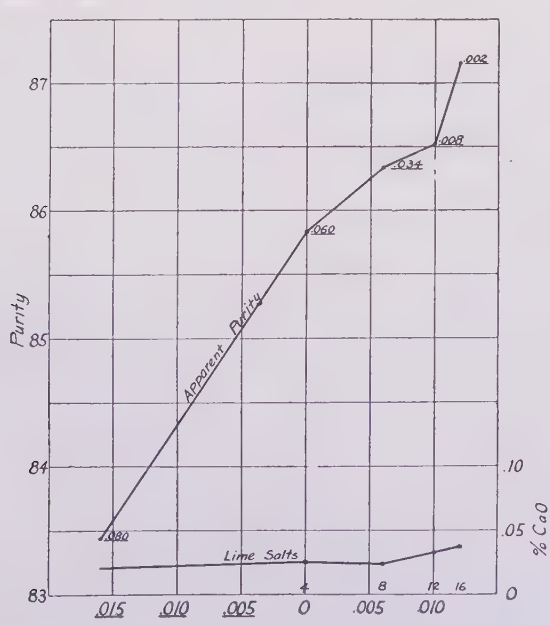

Figure 2.

Though a large increase in apparent purity, 3.73, was secured in this series, it is not certain that this approximated the possible maximum, for neither neutrality to phenolphthalein nor a point showing a decrease in purity was reached. This series differs from the preceding, in that a large increase in purity was found at the neutral point to litmus. Also the increase at this point was a very much larger proportion of the total increase. Lime salts increase slowly at first and afterwards rapidly, the point where the change occurs agreeing closely with the corresponding point in the preceding series.

Table IV and Figure 3 are data for a series in which a somewhat smaller increase in purity, 2.53, was secured and in which the addition of lime was carried considerably beyond the neutral point to phenolphthalein. The juice was D 1135 from Oahu Sugar Co. The purity was low on account of delayed harvesting. In this connection it will be noted that the increase in purity at the neutral point to litmus was very small.

TABLE IV

Treatment	Reaction Litmus	Phenol-phthalein Reaction	Purity		% CaO
			Apparent	Gravity	
Mixed Juice	.012 acid	.064 acid	78.38	.....	.035
3 cc. Lime	.002 alk.	.021 "	78.50	.....	.041
6 " "	.010 "	.014 "	79.50	.....	.056
9 " "	.014 "	.004 "	79.67	81.44	.071
12 " "	.020 "	0	80.91	82.30	.097
15 " "	.028 "	.003 alk.	80.89	81.92	.110
18 " "	.034 "	.005 "	80.73	81.52	.127
21 " "	.038 "	.006 "	80.73	81.48	.152
24 " "	.044 "	.008 "	80.67	81.25	.176

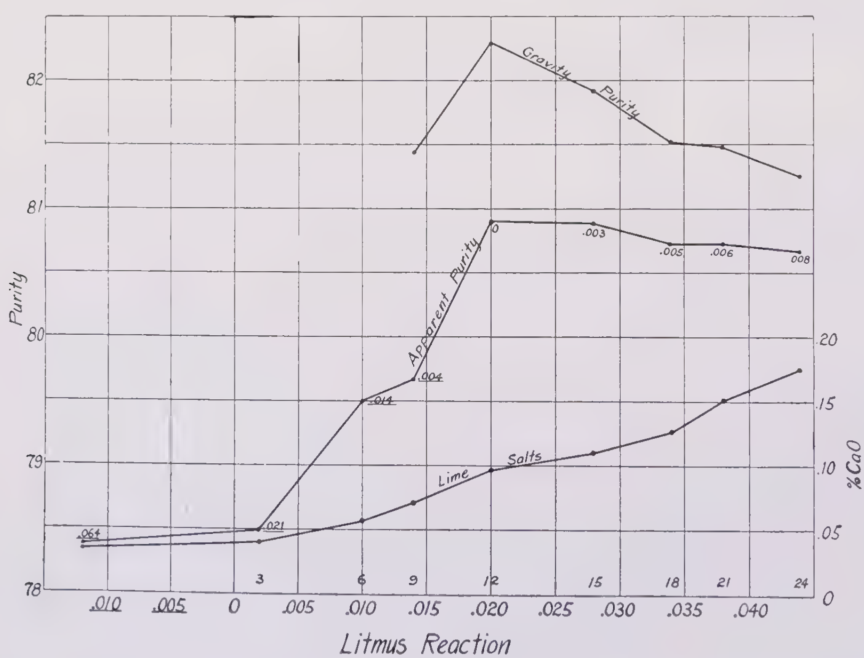

Figure 3.

The maximum increase in both apparent and gravity purity was at the neutral point to phenolphthalein. Past this point there was a gradual decrease in apparent and a rather rapid decrease in gravity purity. The relation of gravity and apparent purity is similar to that shown by the curves in Figure 1. In the portion of the curve immediately on the acid side of the neutral point to phe-

nolphthalein, some two-thirds of the increase in apparent purity is confirmed by the increase in gravity purity.

The lime salts, plotted in Figure 3, begin to increase rapidly at a lower alkalinity than in the two preceding experiments. However, no points are available between .002 and .010 litmus alkalinity. Comparison with other lime salts curves indicates the probability that the change in the lime salts curve would be shown at .006 to .007 litmus alkalinity were these points available.

At phenolphthalein neutrality lime salts were some three times the amount originally in the juice. On the alkaline side of this point the lime salts continue to increase rapidly.

Table V and Figure 4 show data for a series in which an increase in apparent purity of 2.69 was obtained in a very high purity juice. The juice was from Waialua Agricultural Co., and resulted from Yellow Caledonia cane.

TABLE V

Treatment	Reaction Litmus	Reaction Phenol-phthalein	Apparent Purity	% P_2O_5
Mixed Juice	.010 acid	.078 acid	88.46	.074
Filtered Juice	.010 "	.078 "	89.13	.074
2 cc. Lime	.004 "	.058 "	89.37	.059
4 " "	.006 alk.	.038 "	89.76	.023
6 " "	.010 "	.024 "	89.92	.005
8 " "	.016 "	.014 "	90.01	.005
10 " "	.020 "	.007 "	90.50	.005
12 " "	.024 "	.001 alk.	91.15	.005

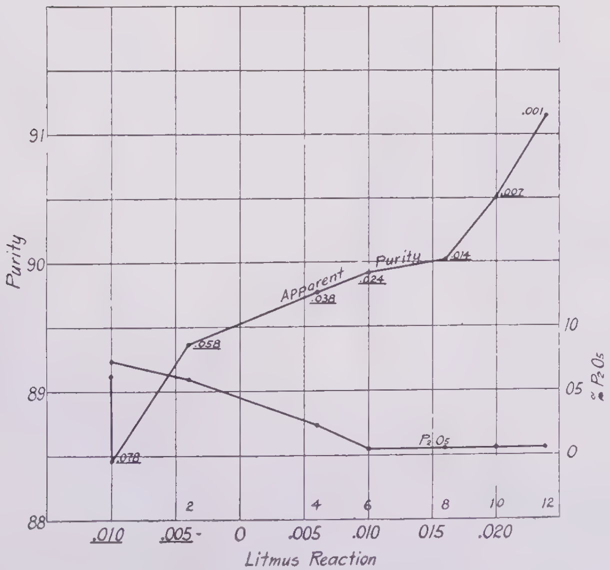

Figure 4.

Though the neutral point to phenolphthalein was passed, the most alkaline juice of the series was the highest in purity, and it is not certain that the maximum was reached. A fair increase in purity was secured at the neutral point to litmus. Lime salts were not determined. In this case the lower curve is the P_2O_5 content. The precipitation of P_2O_5 was in proportion to the change in reaction to litmus, stopping at .010 alkalinity, at which point the percentage was reduced to .005.

The twenty series have been averaged and the results shown graphically in Figure 5. Points in the purity curve were located in the following manner. The

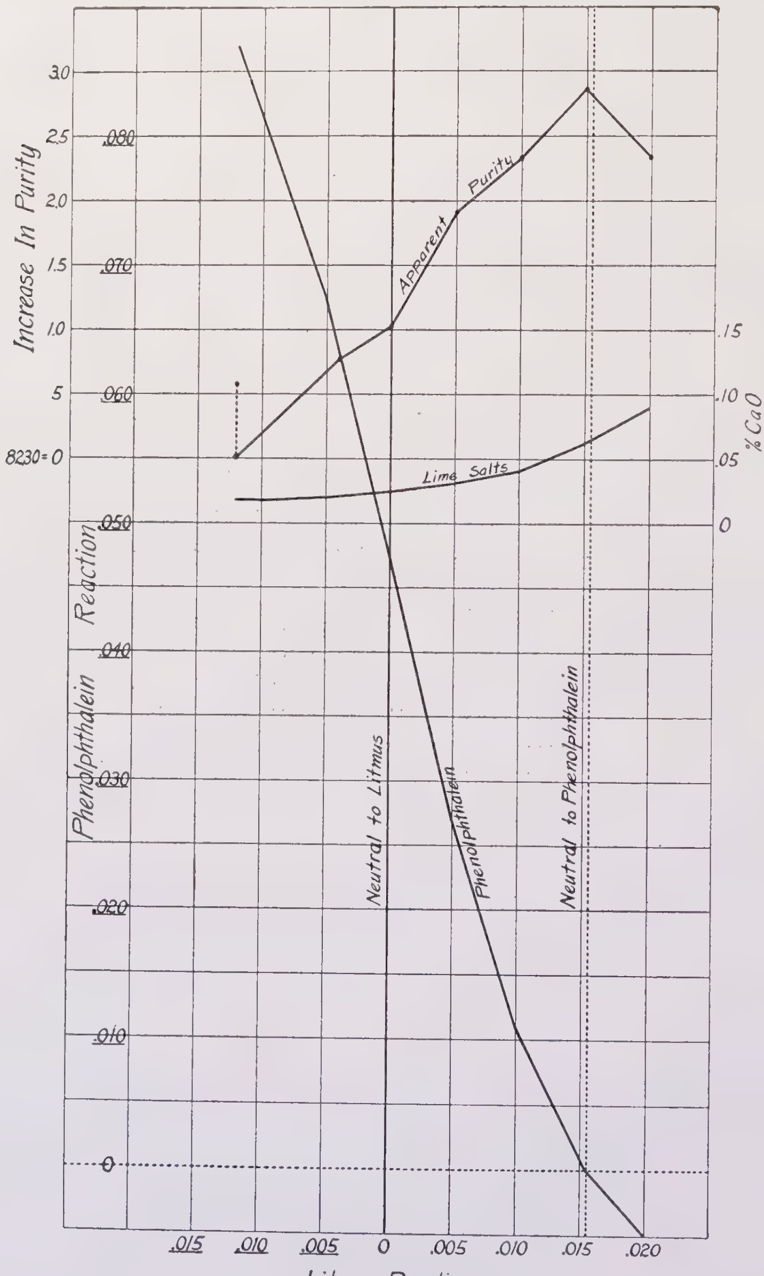

Figure 5.

average acidity of all the original juices was taken as the starting point. Above this the average mechanical increase in purity was plotted. Next all clarified juices between .007 and .003 acid to litmus were averaged and plotted. This range included all the more strongly acid of these juices. The points for juices

between .002 acid and .002 alkaline to litmus, .003 and .007 alkaline, etc., were located in the same manner. The curves for lime salts and phenolphthalein reaction were similarly constructed.

The curve for apparent purity rises rather sharply to the neutral point to litmus, the increase in purity indicated being due to a considerable extent to the removal of suspended matter. The steepest part of the curve is just past the neutral point to litmus. This is followed by a somewhat flattened portion, reaching a maximum at a point closely corresponding to the neutral point to phenolphthalein. After the maximum point the purity curve shows a sharp decrease. Exact figures for points of the purity curve are:

Initial purity	82.30
Maximum increase	2.87
Mechanical increase	0.58
Increase at litmus neutrality	1.0

Six of the series included in the average were on juices from cane that had deteriorated because of delayed harvesting. On account of the tendency of such juices to give a comparatively small increase in purity till after the neutral point to litmus is passed the figure for increase in purity at this point is probably somewhat lower than if sound juices only had been studied. For further information on this point, data for sound and deteriorated juices in Table VI have been averaged separately. The last item in the tabulation is a juice of the second class, failing to give a good increase in purity on clarification. With this item included the increase in purity in the deteriorated juices at litmus neutrality is 45% of the increase at the corresponding point in the sound juices. With this item excluded the ratio is 55%.

Table VI is a comparison of increases in purity at the neutral points of litmus and phenolphthalein. All series in which both points are available are included.

TABLE VI

Juice From Sound Cane

Cane	Mixed Juice Purity	Increase in Purity at Neutral Point to Litmus	Increase in Purity at Neutral Point to Phenolpthalein
H 5001, Experiment Station..	84.28	0.56	1.57
H 5001, Experiment Station..	88.12	1.46	3.02
H 5001, Experiment Station..	83.43	1.31	3.73
Y. C., Aiea	83.2	1.10	2.6
H 109, Experiment Station...	83.9	1.6	2.6
H 109, Aiea	82.24	0.64	3.0
Average	84.36	1.11	2.75

Juice From Deteriorated Cane

Lahaina, Aiea	75.49	0.48	3.11
D 1135, Waipahu	76.82	0.16	2.22
Lahaina, Aiea	75.48	1.22	2.96
D 1135, Waipahu	78.35	0.12	2.53
Lahaina, Aiea	75.52	1.07	4.34
Y. C., Waimanalo	74.07	–0.07	0.53
Average	75.9	0.50	2.62

It will be noted that in juices from sound cane the increase in purity at litmus neutrality was 40% of the increase at phenolphthalein neutrality. In juices from deteriorated cane it was 19%. The increase in purity, shown in the last column, was not in all cases the maximum.

The lime salts curve in Figure 5 shows a gradual increase to a point about midway between litmus and phenolphthalein neutrality. Beyond this point the increase is more pronounced. At phenolphthalein neutrality, lime salts are approximately three times the original amount.

As previously noted the increase in apparent purity is due principally to the removal of impurities, but is also due to some extent, particularly in the more alkaline juices, to the change in the ratio of polariation to sucrose. Gravity purities are not available for a sufficient number of series to plot a gravity purity curve in Figure 5 for comparison with the apparent purity. The following figures, however, are the averages of six clarification series in which both gravity and apparent purities are available.

Reaction to litmus	.010	.002	.004	.008	.012	.015	.019
Gravity Purity	82.30	83.15	83.65	84.45	84.97	84.55	84.55
Apparent Purity	81.27	82.19	82.77	83.64	84.30	84.08	84.31
Difference	1.03	.96	.88	.81	.67	.47	.24

Over 90% of the increase in purity indicated by the apparent purity figures is confirmed by figures for gravity purity till .008 litmus alkalinity is reached. From .008 to .012 alkalinity some 80% of the increase in apparent purity is confirmed. At higher alkalinities differences between apparent and gravity purities rapidly decrease.

Litmus and phenolphthalein give entirely dissimilar indications, not only with respect to the neutral point, but in the relative results obtained on titrating. The curve for the relation of litmus to phenolphthalein reaction in Figure 5 has been plotted not so much in an attempt to establish a definite relation between them as to remove some of the confusion that exists as to the indications given by the two indicators when used in cane juice. The curve shows juice neutral to litmus to have an acidity of .047 to phenolphthalein. In juice neutral to phenolphthalein, however, an alkalinity of but slightly over .015 to litmus is shown. Approximately the same ratio of three to one holds good from litmus neutrality to the acidity of the original juice. The individual points for juices of the first class lay close to the curve, indicating that it may be taken as fairly representative of this relation in such juices. With juices of the class that do not clarify

satisfactorily a different relation exists, particularly in the region between the neutral points of the two indicators.

Juices That Do Not Clarify Well.

We include in this class juices that on clarification will not give a large increase in purity and that will not settle in a reasonable time, leaving a clear solution. The only available clarification series that is at all complete on a juice of this class, is on Yellow Caledonia juice from Waimanalo plantation. All members of the series settled poorly and the maximum increase in purity was small. Data for the series are in Table VII.

TABLE VII

Treatment	Apparent Purity	Reaction Litmus	Reaction Phenol.	% P_2O_5
Mixed Juice	74.07	.012 acid	.083 acid	.029
Filtered Juice	74.65	.012 "	.083 "	....
3 ccs. Lime	74.00	Neutral	.048 "	.023
6 " "	74.83	.020 alk.	.038 "	.007
9 " "	74.74	.030 "	.018 "	.006
12 " "	74.23	.040 "	.012 "	.006
15 " "	74.60	.050 "	.006 "	.005
18 " "	74.74	.055 "	.002 "	.006
21 " "	74.60	.060 "	Neutral	.005

This juice differed from juices of the first class, not only in settling and size of the increase in purity, but also in the relation of phenolphthalein and litmus reaction, and in the lime requirement. From the acidity of the mixed juice to the neutral point to litmus the relation of phenolphthalein and litmus reaction agrees approximately with the curve in Figure 5. At neutrality to phenolphthalein, however, the alkalinity to litmus is .060 instead of close to .015, the figure indicated by this curve. Compared with juices of the class that clarify satisfactorily, the amount of lime required to reach the neutral point to litmus is about what would be expected. Between litmus and phenolphthalein neutrality a given amount of lime caused about the expected change in reaction to phenolphthalein, but some four times the change in litmus reaction that would be inferred from previous series. The maximum increase in purity was secured with 6 cc. of lime per liter. The reaction at this point was .020 alkalinity to litmus and .038 acidity to phenolphthalein. The litmus reaction of the point of maximum increase in purity was in fair agreement with that for the point of maximum increase in series on the other class of juices. Phenolphthalein reaction at this point and the amount of lime required to reach it do not, however, agree at all with previous results. The maximum increase in purity, 0.76, is but 0.18 higher than the increase obtained by filtration alone. There was a decrease in purity at the neutral point to litmus. In the more alkaline members of the series the purities were quite irregular.

While the data available for this class of juice do not go far toward defining either the size of the possible increase in purity or the reaction at which

the maximum can be obtained, considerable data are available pointing toward a close relation between low phosphoric acid content and the characteristics shown by this class of juices.

Attention was first directed to the phosphoric acid content while examining juices giving turbid settled juice and small increases in purity at Oahu Sugar Co. D 1135 juice that settled most unsatisfactorily, after the addition of disodium phosphate equivalent to 0.02% P_2O_5 and liming to the point where the P_2O_5 was precipitated, gave a clear, almost limpid settled juice. H 109 juice also giving trouble contained .015% P_2O_5. Increasing the P_2O_5 to .035% resulted in clear settled juices. Lahaina juice with .027% P_2O_5 was giving a fair, though not by any means clear, settled juice. Following this examination a soluble phosphate was used in the factory while these juices were handled and excellent settling was secured. Better settling was accompanied by a better increase in purity. It is probable that this was due to the fact that the clarification was conducted at a more alkaline reaction, rather than to actual precipitation of impurities by the phosphate added.

The Waimanalo sample which did not settle or give a good increase in purity (Table VII) contained .029% P_2O_5. On clarification this was reduced to .006% in the more alkaline members of the series. A sample of Yellow Caledonia juice from Waialua (Table V and Figure 4) gave a clear settled juice and a fairly large increase in purity. This juice contained .074% P_2O_5. The P_2O_5 content was reduced at .010 litmus alkalinity to .005%. A sample of juice from Ewa gave an increase in purity of 2.8 and well settled juice. The P_2O_5 content was .034%. This was reduced to .004% in the more alkaline clarified juices.

Six samples of juice were clarified with 5 and 8 cc. of lime, with the object of further studying the phosphate content. The data are in Table VIII.

TABLE VIII

Sample	Mixed Juice				Clarified Juice 5 ccs. Lime per Liter				Clarified Juice 8 ccs. Lime per Liter			
	Apparent Purity	Reaction *	% CaO	% P_2O_5	Purity Increase	Reaction *	% CaO	% P_2O_5	Purity Increase	Reaction *	% CaO	% P_2O_5
1	91.23	.014 acid	.013	.099	1.90	.006 alk.	.017	.010	2.58	.012 alk.	.038	.011
2	92.38	.010 ''	.013	.092	2.83	.006 ''	.019	.013	3.12	.012 ''	.035	.010
3	91.37	.010 ''	.013	.102	1.45	.006 ''	.018	.010	2.66	.012 ''	.033	.007
4	92.11	.010 ''	...	.038	.89	.014 ''	...	.007	2.56	.018 ''	...	.007
5	90.9	.010 ''	.014	.016	1.1	.014 ''	...	...	1.1	.018 ''	.105	.010
6	86.8	.008 ''	.017	.011	−0.4	.024 ''	.077	.011	−0.1	.028 ''	.116	.010

* Referred to litmus.

Samples Nos. 1, 2, and 3 are, respectively: Lahaina, H 109, and D 1135 cane from the Experiment Station plots in Honolulu. The P_2O_5 content is high and does not differ materially in the different varieties. They gave well settled

juices and satisfactory increases in purity on clarification. Samples No. 4 was Lahaina juice from Field 25, Oahu Sugar Co. This sample, containing .038% P_2O_5 gave well settled clarified juices and a good increase in purity. Samples 5 and 6 are H 109 juices from Experiment 6, Field 45, Oahu Sugar Co. No. 6 is from the check plots receiving no phosphate fertilization, while No. 5 is from the "C" plots, to which 90 pounds P_2O_5 in the form of superphosphate, were used per acre. Sample No. 5, with .011% P_2O_5, gave extremely poor results on clarification. A decrease in purity resulted and the settled juices were very turbid. Sample No. 6, with .016% P_2O_5, gave slightly better results. A 1.1 increase in purity was secured; the settling, however, was but little better than in No. 5.

The large increase in alkalinity to litmus caused by a comparatively small amount of lime in low phosphate juices is evident in this tabulation. The clarified juices of samples Nos. 5 and 6 were also high in lime salts.

In connection with the phosphate content shown in Table VIII, we would note that the Experiment Station plots are high in available P_2O_5.[5] It is probable that the juices previously examined from these plots had a P_2O_5 content similar to samples 1, 2, and 3. Field 45 is low in available P_2O_5 and responds to phosphate fertilization. Such fertilization evidently improved the juice from the C plots, but did not raise the P_2O_5 content sufficiently to class it with juices giving satisfactory clarification.

In this investigation all juices, with but one or two exceptions, that have given clear settled juices have given increases in purity of 2.5 or more when at all complete clarification series have been run. On the contrary, juices that have not given clear settled solutions have in no case given large increases in purity. All of the latter class have been low in P_2O_5 content.

The action of the phosphoric acid in clearing up the juice appears to be mechanical, the heavy precipitate of calcium phosphate carrying down the coagulated colloids. Though definite conclusions as to settling under factory conditions can hardly be drawn from laboratory experiments. According to all present information we are inclined to place the dividing line between the two classes of juice at from .030 to .035 parts of P_2O_5 per 100 parts of juice.

There is little available information as to the phosphate content of Hawaiian juices. Judging from observation of the clarification at the different factories, however, it seems probable that a very large proportion are of the class that clarify well.

Practical Considerations.

With juices of the class that clarify well a decided improvement in the increase in purity is secured by carrying the clarification at a more alkaline point than is the common practice. Clarification practice in Hawaiian factories varies to a considerable extent. There are still a few factories where the clarified juice is acid to litmus. In a few, very alkaline clarification has been adopted. In most of the factories, however, the clarification is at close to the neutral point to litmus, and a decided prejudice exists against passing this point to any extent.

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[5] Record, Vol. 26, No. 1.

In juices of the first class the maximum increase in both apparent and gravity purity has been obtained at the neutral point to phenolphthalein, the increase in apparent purity at this point being anywhere from two to four times the increase at the neutral point to litmus. Difficulties in settling need not be anticipated even when going as far as phenolphthalein neutrality, except in cases where settling and filter press capacity are very limited. While the volume of the settlings increased apparently more than in proportion to the increased amount of impurities precipitated at the higher alkalinities, in none of the juices investigated have increased amounts of lime caused the settled juices to be less clear, till the neutral point to phenolphthalein has been passed. After this point the settling was in a few cases unsatisfactory. Lime salts were usually three times the original amount at the neutral point to phenolphthalein. The effect of this on incrustation of heating surfaces cannot be predicted from present information. Glucose was attacked by lime to some extent before reaching the neutral point to phenolphthalein. Whether or not this was to an extent that would cause difficulties with the low grades also cannot be predicted from laboratory results. Whether or not, then, it is practicable to carry the liming to a point where the clarified juices are neutral to phenolphthalein and so secure the whole of the possible increase in purity can only be determined by carefully controlled factory practice.

It will be noted, however, that at a point midway between litmus and phenolphthalein neutrality, corresponding to about .008 litmus alkalinity, a very large part of the possible increase in gravity purity was secured. At this point lime salts have increased but slightly and glucose has not been attacked to any material extent. While it may not be practicable to carry the clarification at the neutral point to phenolphthalein, carrying it at this point appears feasible. Both analytical data and results secured in factories now using an alkaline clarification indicate that complications are improbable in carrying the clarification at this point.

Unfortunately this point is sufficiently alkaline to litmus so that the color change of litmus paper loses much of its value for definitely locating it. The point is acid to phenolphthalein, so this indicator does not show any color reaction and cannot be used directly. It can, however, be definitely located by titrating the clarified juice. At very close to this point the clarified juice usually shows the change from a reddish yellow to a clear light yellow color that is sometimes termed "over-liming." This change usually occurred just before this point was reached. We have also found that if the cold juice is limed till neutral to phenolphthalein, after heating the clarified juice will be at close to the desired reaction.

The point we have been discussing is in quite close agreement with the point referred to several times, though not directly recommended, by Deerr in the revised edition of Cane Sugar. This is "an acidity of 0.5 cc. normal per 100 cc. referred to phenolphthalein as an indicator." It is not at all in agreement with the suggestion of Prinzen Geerligs, that lime be added till no further precipitate is formed on adding calcium sucrate to the clarified juice. We have found that calcium sucrate forms a precipitate in hot clarified juice till a moderate alkalinity to phenolphthalein is reached. A reaction as alkaline as this is

undesirable, for at such a point we have usually found decreases from the maximum purity, and difficulties due to the use of an excessive amount of lime may be anticipated.

The above recommendations are for juices of the class that clarify satisfactorily. Present information does not permit us to specify as closely the point to which liming should be carried in juices of the class that do not clarify satisfactorily. They should be alkaline to litmus to avoid inversion. There are indications, however, that adding lime till the clarified juice is neutral to phenolphthalein, or even midway between litmus and phenolphthalein neutrality, is undesirable. Poor settling in these juices can be corrected and clear settled juice secured by adding a soluble phosphate in such proportion that the P_2O_5 content is brought up to from .03 to .035%. When this is done lime should be added till the clarified juices have an alkalinity to litmus of approximately .008, so that the maximum precipitation of P_2O_5 takes place. If the clarification is properaly conducted all the P_2O_5 that has been added is recovered in the press cake in the form of a finely divided precipitate, fairly available as plant food. As the fertilizer value of the phosphate used is thus realized, a deduction of this value may be made in estimating the cost of securing clear, well settled juice when working juices of the class that do not clarify satisfactorily.

This investigation of clarification is being continued and no doubt further information on the questions already taken up will be obtained.

Sugar Prices

96° Centrifugals for the Period

December 16, 1921, to March 15, 1922.

Date	Per Pound	Per Ton	Remarks
Dec. 16, 1921	3.765 ¢	$75.30	Old and new Cubas.
" 20	3.735	74.70	Delayed sale, old crop Cubas.
" 21	3.73	74.60	Made up, Philippines 3.60, old crop Cubas 3.86.
" 22	3.86	77.20	Old Cubas.
" 23	3.6367	72.734	Spot Cubas 3.86, for new shipment 3.51 and 3.54.
" 24	3.86	77.20	Spot old Cubas.
" 27	3.64	72.80	Spot Cubas Committee 3.86, Nearby new 3.42.
" 28	3.61	72.20	Old spot 3.86, new 3.36.
" 29	3.73	74.60	Spot Cubas.
Jan. 3, 1922	3.61	72.20	Spot Cubas.
" 4	3.61	72.20	Spot old Cubas.
" 6	3.545	70.90	Non-controlled 3.48, Committee 3.61.
" 7	3.61	72.20	Committee old Cubas.
" 9	3.575	71.50	Average, Committee old Cubas 3.61, old crop 3.54.
" 10	3.575	71.50	Average, Committee old Cubas 3.61, old crop 3.54.
" 11	3.575	71.50	Uncontrolled old Cubas 3.54, Committee 3.61.
" 12	3.61	72.20	Committee old Cubas.
" 13	3.575	71.50	Average, Porto Ricos 3.54, Committee old Cubas 3.61.
" 14	3.61	72.20	Committee old Cubas.
" 16	3.575	71.50	Uncontrolled old Cubas 3.61, Philippines 3.54.
" 17	3.61	72.20	Old Cubas.
" 19	3.6917	73.834	Committee old Cubas 3.61, old Cubas 3.73, Philippines 3.735.
" 20	3.7625	75.25	Philippines 3.735, old Cubas 3.79.
" 21	3.86	77.20	Old Cubas.
" 25	3.81	76.20	Porto Ricos 3.76 and 3.86.
" 26	3.76	75.20	Porto Ricos.
" 27	3.70	74.00	Average 3.73, old Cubas 3.67.
" 31	3.73	74.60	Old Cubas.
Feb. 1	3.61	72.20	Porto Ricos.
" 2	3.64	72.80	Old new Cubas 3.67, Porto Ricos 3.61.
" 3	3.67	73.40	Old Cubas.
" 9	3.575	71.50	Old Cubas 3.61, Porto Ricos 3.54.
" 10	3.605	72.10	Cubas 3.67, Porto Ricos 3.54.
" 15	3.605	72.10	Old Cubas 3.67, Porto Ricos 3.54.
" 16	3.635	72.70	New Cubas 3.73, Porto Ricos 3.54.
" 17	3.79	75.80	Old Cubas 3.79, new Cubas 3.79.
" 18	3.86	77.20	New Cubas.
" 20	3.86	77.20	Old and new Cubas.
" 24	3.70	74.00	Old and new Cubas.
" 27	3.635	72.70	New Cubas 3.73, Porto Ricos 3.54.
Mar. 1	3.70	74.00	New Cubas 3.79, Porto Ricos 3.61.
" 2	3.69	73.80	New Cubas 3.79, Porto Ricos 3.61 and 3.67.
" 3	3.67	73.40	New Cubas 3.73, Porto Ricos 3.61.
" 4	3.73	74.60	Old Cubas.
" 6	3.79	75.80	New Cubas.
" 8	3.7833	75.666	New Cubas 3.79 and 3.86, Porto Ricos 3.70.
" 9	3.81	76.20	New Cubas 3.86, Philippines 3.76.
" 10	3.89	77.80	New Cubas 3.89 and 3.92, Porto Ricos 3.86.
" 11	3.86	77.20	Philippines.
" 13	3.92	78.40	Old Cubas.
" 14	3.89	77.80	New Cubas 3.86, old and new Cubas 3.92.